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K7102	Metal Detector Kit	7.62
K7105	Handheld LCD Oscilloscope Kit	135.28
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K8029	Slow On-Off Dimmer Kit	13.60
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K8033	Power Blinker Kit	13.04
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K8051	15-Channel IR Remote Stick Kit	14.35
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K8087	Telephone Ring with Buzzer and LED Kit	10.83
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K8099	Nixie Clock Kit	64.96
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MK104	Electronic Cricket Minikit	6.73
MK105	Signal Generator Minikit	4.21
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MK109	Electronic Dice Minikit	4.45
MK110	Simple One Channel Light Organ Minikit	5.84
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MK113	Siren Sound Generator Minikit	5.40
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MK116	Riding Santa Minikit	12.45
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MK119	Roulette Minikit	11.82
MK120	Light Barrier Minikit	6.90
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MK131	Traffic Light Minikit	6.85
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MK145	Halloween Pumpkin Minikit	7.63
MK146	Pocket VU Meter Minikit (with Enclosure)	7.44
MK147	Dual White LED Stroboscope Minikit	5.20
MK148	Dual Super Bright Flashing Red Lights	4.43
MK149	Love Tester Minikit	11.15
MK150	Shaking Dice Minikit	8.49
MK151	Digital LED Clock Minikit	15.09
MK152	Wheel of Fortune Minikit	3.95
MK153	Jumbo Single Digit Clock Minikit	12.53
MK154	5 in 1 Emergency Tool Minikit	11.84
MK155	Magic Message Minikit	11.84
MK157	LCD Mini Message Board Minikit	15.96
MK158	LCD Mini Message Board with Backlight	21.14
MK159	Brain Game Minikit	10.47
MK160	Remote Control via GSM Mobile Phone	8.93
MK161	2-Channel IR Remote Receiver Minikit	9.95
MK162	2-Channel IR Remote Transmitter Minikit	8.49
MK163	Electronic Stereo Volume Control Minikit	10.90
MK164	IR Electronic Volume Control Minikit	14.79
MK165	Crawling Bug Minikit	13.89
MK166	Animated Ghost Minikit	9.09
MK167	Electronic Candle Minikit	3.81
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MK169Y	Flashing LED Star (Yellow) Minikit	6.20
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MK172	Sound LED Star Minikit	7.83
MK173	Mini 6-LED Chaser Minikit	8.50
MK174	Single-Message Record/Playback Minikit	11.87
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MK177	Ding Dong Minikit	4.90
MK178	3rd Brake Light Flasher Minikit	6.30
MK179	Proximity Card reader Minikit	14.25
MK180	2 Channel Hi-power LED Flasher Minikit	10.50
MK181	AC Power voltage indicator LED Minikit	2.43
MK182	Digital Echo Chamber Minikit	11.43

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VM100	200W Power Amplifier Module	38.54
VM101	Multifunctional Dimmer Module	34.90
VM103	Blinking Module	34.43
VM105	AC Power Slave Module	34.43
VM106	Video Signal Cleaner Module	30.44
VM107	Multifunctional Counter Module	38.91
VM110	USB Interface Card Module	34.90
VM111	PIC Programmer and Experiment Module	32.60
VM112	Personal Animated Badge Module	19.95
VM113	Stereo Amplifier Module 2 x 30W	19.25
VM114	7W Mono Audio Amplifier Module	7.95
VM116	USB Controlled DMX Interface Module	67.15
VM118	8-Channel RF Remote Control Set Module	68.77
VM118R	8-Channel RF Remote Transmitter Module	36.02
VM119	One Channel Dual Output Receiver	19.40
VM120	10-Channel Light Effect Generator	32.02
VM121	15-Channel Infrared Transmitter Module	36.02
VM122	15-Channel Infrared Receiver Module	29.62
VM124	1A Power Supply Module	6.50
VM125	Ultrasonic Radar Module	26.54
VM129	8-Channel Relay Card Module	33.29
VM130	2-Channel RF Remote Control Set Module	35.45
VM130T	2-Channel RF Remote Control Transmitter	12.90
VM131	Dimmer for Electronic Transformers	24.04
VM132	Universal Temperature Sensor Module	13.04
VM133	Energy Saver Module	18.15
VM134	PIC Programmer Board Module	36.90
VM135	Magical Dimmer Module	13.58
VM136	Interval Timer Module	6.30
VM137	Thermostat Module 5° - 30°C Module	7.95
VM138	DMX Controlled Relay Module	21.74
VM139	IR Remote Checker Module	7.64
VM140	Extender USB Interface Board Module	79.95
VM141	Start/Stop Timer Module	12.95
VM142	Mini-Pic Application Module	26.00
VM143/1W	1W High Power LED Driver Module	9.85
VM143/3W	3W High Power LED Driver Module	9.95
VM144	Telephone Ring Detector & Relay output	14.65
VM145	Digital Panel Thermometer Min/Max	23.35
VM146	RGB Controller Module	22.52
VM147	Panel Counter Module	23.35
VM148	Panel Thermostat Module	26.80
VM150	RGB LED Dimmer for DIN rail *(Due July)*	31.00
VM151	RGB Controller Module & remote control	26.35
VM152	LED Dimmer with RF Remote Control	29.53
VM154	Fan Timer Module	17.55
VM156	Pocket Audio Generator Module	20.00
VM160	4 Channel RF Remote Control Set	47.50
VM160DT	4 Channel RF Desktop Transmitter	46.28
VM160T	4 Channel RF Replacement transmitter	17.05
VM161	RGB LED Strip Colour controller Module	22.75
VM162	RGB LED Strip Colour dimmer Module	30.86
VM163	Panel Clock Module	25.17
VM164	Mini Dimmer, Push button control *(Due July)*	14.78
VM165	0-10V DC Controlled Dimmer *(Due June)*	48.95
VM179	Proximity Card Reader Module	25.65
VM8090	8 Channel USB Relay Card *(Due July)*	58.40

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● PROJECTS ● THEORY ●
● NEWS ● COMMENT ●
● POPULAR FEATURES ●

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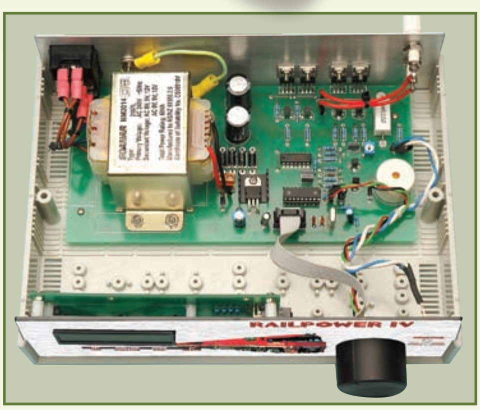

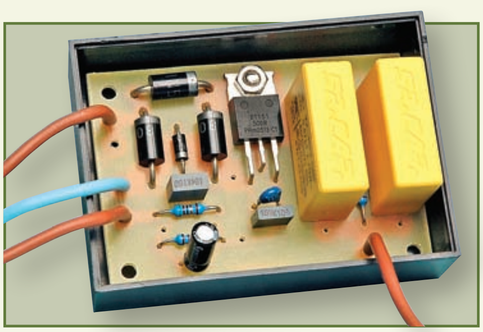

Projects and Circuits

Series and Features

Regulars and Services

Our November 2010 issue will be published on Thursday 14 October 2010, see page 72 for details.

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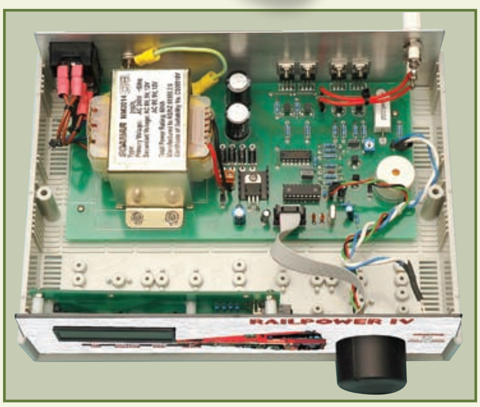

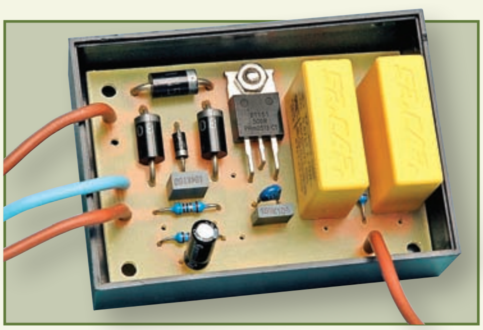

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Series and Features

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PIC & ATMEL Programmers

We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

Programmer Accessories:
40-pin Wide ZIF socket (ZIF40W) £14.95
18Vdc Power supply (PSU120) £19.95
Leads: Parallel (LDC136) £3.95 / Serial (LDC441) £3.95 / USB (LDC644) £2.95

NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149EKT - **£49.95**
Assembled Order Code: AS3149E - **£59.95**
Assembled with ZIF socket Order Code: AS3149EZIF - **£74.95**

NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.
Assembled Order Code: AS3128 - **£49.95**
Assembled with ZIF socket Order Code: AS3128ZIF - **£64.95**

ATMEL 89xxxx Programmer

Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.
Kit Order Code: 3123KT - **£28.95**
Assembled Order Code: AS3123 - **£39.95**

Introduction to PIC Programming

Go from complete beginner to burning a PIC and writing code in no time! Includes 49 page step-by-step PDF Tutorial Manual, Programming Hardware (with LED test section), Win 3.11—XP Programming Software (Program, Read, Verify & Erase), and 1rewritable PIC16F84A that you can use with different code (4 detailed examples provided for you to learn from). PC parallel port.
Kit Order Code: 3081KT - **£16.95**
Assembled Order Code: AS3081 - **£24.95**

PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: K8076KT - **£39.95**

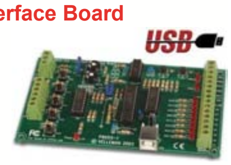
PIC Programmer & Experimenter Board

The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: K8048KT - **£39.95**
Assembled Order Code: VM111 - **£59.95**

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £7.95

USB Experiment Interface Board



5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: K8055KT - **£38.95**
Assembled Order Code: VM110 - **£64.95**

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two *& Ten Channel versions also available.*
Kit Order Code: 3180KT - **£49.95**
Assembled Order Code: AS3180 - **£59.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£19.95**
Assembled Order Code: AS3145 - **£26.95**
Additional DS1820 Sensors - **£3.95 each**

Remote Control Via GSM Mobile Phone

Place next to a mobile phone (not included). Allows toggle or auto-timer control of 3A mains rated output relay from any location with GSM coverage.
Kit Order Code: MK160KT - **£13.95**

Most items are available in kit form (KT suffix) or pre-assembled and ready for use (AS prefix).

4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£74.95**
Assembled Order Code: AS3140 - **£89.95**

8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£69.95**
Assembled Order Code: AS3108 - **£84.95**

Infrared RC 12–Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£59.95**
Assembled Order Code: AS3142 - **£69.95**

Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic *or* direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£34.95**
Assembled Order Code: AS3153 - **£44.95**

Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).
Kit Order Code: 3164KT - **£44.95**
Assembled Order Code: AS3164 - **£59.95**

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Teach-In 2011

Hard to believe that we only have two issues for 2010 left, but what better way to round off the year than by launching a new Teach-In series.

Teach-In 2011 has been designed to provide you with a broad-based introduction to electronics. We'll cover three of the most important electronics units that are currently studied in schools and colleges in the UK. These include Edexcel BTEC Level 2 awards, as well as electronics units of the new Diploma in Engineering (Level 2). The series will also provide more experienced readers with an opportunity to 'brush up' on specific topics.

Teach-In 2011 is organised under five main headings: Learn, Check, Build, Investigate and Amaze. Learn will teach you the theory; Check will help you to check your understanding; and Build will give you an opportunity to build and test circuits. Investigate will provide you with a challenge that will allow you to extend your learning; and finally, Amaze will show you the 'wow factor'!

Next month, Part 1 starts the series by introducing the signals used to convey information in electronic circuits and the units that we use to measure electronic quantities. We'll also introduce you to 'Circuit Wizard', a versatile circuit simulation package that runs on a standard Windows PC. Part 2 looks at resistors, capacitors, timing and delay circuits, while Part 3 deals with diodes and power supplies. Transistors are introduced in Part 4, and operational amplifiers in Part 5.

Logic circuits (including gates, monostables and bistables) are explained in Part 6, and timers are introduced in Part 7. Part 8 is devoted to a variety of analogue circuit applications (including amplifiers and filters). Part 9 describes digital circuit applications (including counters and shift registers). Finally, Part 10 rounds off the series with an introduction to microprocessors and PICs.

Matt

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years' old. Letters requiring a personal reply must be accompanied by a stamped self-addressed envelope or a self-addressed envelope and international reply coupons. We are not able to answer technical queries on the phone.

PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.
We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment, as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; readers should check local laws.

EVERYDAY PRACTICAL ELECTRONICS

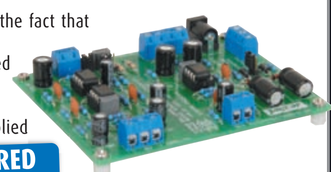
FEATURED KITS

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested down under.
All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

October 2010

BALANCED TO UNBALANCED AUDIO CONVERTER

KC-5468 £9.75 plus postage & packing
Using domestic audio equipment in a professional environment is complicated by the fact that standard audio gear does not have the balanced inputs and outputs found in professional systems. This kit overcomes the problem and will adapt an unbalanced input to balanced output and vice versa. This allows domestic equipment to be integrated into a professional installation while maintaining the inherent high immunity to noise pick-up on long cable runs provided by balanced lines. Kit supplied with solder masked PCB and all specified components.

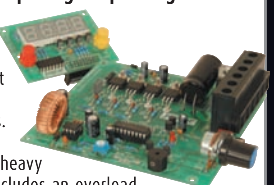


Featured in this issue of EPE

FEATURED THIS MONTH

12-24V HIGH CURRENT MOTOR SPEED CONTROLLER KIT

KC-5465 £26.25 plus postage & packing
Controls a 12 or 24VDC motor at up to 40A continuous and features automatic soft-start, fast switch-off and a 4-digit display to show settings. Speed regulation is maintained even under heavy loads and the system includes an overload warning buzzer and a low battery alarm. Kit contains PCB and all specified electronic components.



Featured in EPE Dec 2009/Jan 2010

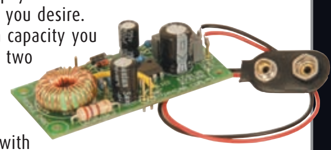
AC/DC CURRENT CLAMP METER KIT FOR DMMS

KC-5368 £10.25 plus postage & packing
A great low cost alternative to expensive current clamp meters. It uses a simple hall effect sensor and iron ring core setup, and connects to your digital multimeter. It will measure AC and DC current and has a calibration dial to allow for any magnetising of the core. Much cheaper than pre-built units. Kit supplied with PCB, clamp, case with silkscreened front panel and all electronic components.

Featured in EPE Magazine Jan 2006

3V TO 9V DC TO DC CONVERTER KIT

KC-5391 £4.75 plus postage & packing
This great little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no-time! You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell. Kit supplied with PCB, and all electronic components.



Featured in EPE June 2007

BRIDGE MODE ADAPTOR FOR STEREO AMPLIFIERS

KC-5469 £8.25 plus postage & packing
This excellent kit will let you run a stereo amplifier in 'Bridged Mode' to effectively double the power available to drive a single speaker. There are no modifications required on the amplifier and the signal processing is done by the kit before the signals are fed to the stereo amp. The kit is perfect for say, using a stereo amplifier as an occasional PA amplifier for social functions or using an old amplifier to drive a sub-woofer in a home theatre system. It sounds like magic, but is just a clever adaptation of basic electronic principles. Kit supplied with silk screened PCB and all specified components. Requires balanced (+/-) power supply.

PCB: 103 x 85mm

Featured in this issue of EPE

FEATURED THIS MONTH

IMPROVED LOW VOLTAGE ADAPTOR

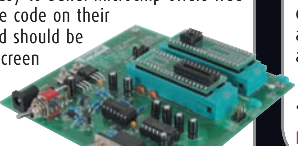
KC-5463 £5.25 plus postage & packing
A handy regulator to run a variety of devices such as CD or MP3 players from your car cigarette lighter sockets or even powered speakers from the power supply inside your PC. It will supply either 3V, 5V, 6V, 9V, 12V or 15V and (when used with an appropriate input voltage and heatsink) deliver up to four amps at the selected output voltage. Kit includes screen printed PCB and all specified components. Heatsink not included.

- PCB Dimensions: 108 x 37mm

Featured in EPE September 2010

PIC MICROCONTROLLER SERIAL PROGRAMMER KIT

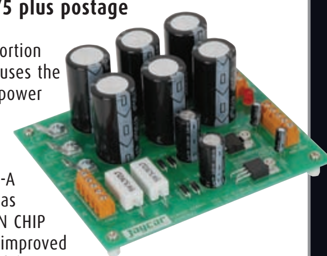
KC-5467 £21.75 plus postage & packing
This very cost effective programmer kit can handle all the dsPIC30F family and almost all of the regular PICs available in a DIP package. It uses freely available software for PCs and is easy to build. Microchip offers free documentation and source code on their website so getting started should be a breeze. Supplied with screen printed PCB, 2 x 40 pin ZIF sockets and all specified components.



Featured in EPE May 2010

ULTRA-LOW DISTORTION 135WRMS AMPLIFIER MODULE

KC-5470 £27.75 plus postage & packing
This ultra low distortion amplifier module uses the new ThermalTrak power transistors and is largely based on the high-performance Class-A amplifier which was featured in SILICON CHIP during 2007. This improved circuit has no need for a quiescent current adjustment or a Vbe multiplier transistor and has an exceptionally low distortion figure. Kit supplied with PCB and all electronic components. Heat sink and power supply not included.



Output Power: 135WRMS into 8 ohms and 200WRMS into 4 ohms
Frequency Response at 1W: 4Hz to 50kHz
Harmonic Distortion: <0.008% from 20Hz to 20kHz

Also available:
Power Supply Kit for Ultra-LD Mk2 200W Amplifier (KC-5470) - KC-5471 £16.25

Featured in EPE August/September 2010

LOW COST PROGRAMMABLE INTERVAL TIMER KIT

KC-5464 £10.25 plus postage & packing
Here's a new and completely updated version of the very popular low cost 12VDC electronic timer. It is link programmed for either a single ON, or continuous ON/OFF cycling for up to 48 on/off time periods. Selectable periods are from 1 to 80 seconds, minutes, or hours and it can be restarted at any time. Kit includes PCB and all specified electronic components.

- PCB: 102 x 42mm

Featured in EPE August/September 2010

VOLTAGE MONITOR KIT

KC-5424 £6.75 plus postage & packing
This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that illuminate in response to the measured voltage, preset 9-16V, 0-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night time driving. Kit includes PCB with overlay, LED bar graph and all electronic components.

- 12VDC
- Recommended box: UB5 use HB-6015 £0.83

Featured in EPE November 2007

THE 'FLEXITIMER'

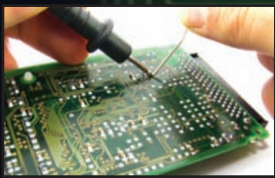
KA-1732 £6.00 plus postage & packing
This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices and can be powered by a battery or mains plugpack.

- Kit includes PCB and all components
- Requires 12 - 15 VDC power

Featured in EPE May/June 2008

Jaycar Electronics

Freecall order: 0800 032 7241

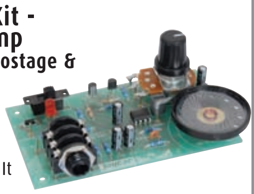


SIGHT & SOUND KITS FOR ELECTRONIC ENTHUSIASTS

GUITAR KITS

4 Channel Versatile Mixer Kit
KC-5448 £28.75 plus postage & packing
This is an improved version of our popular guitar mixer kit and has a number of enhancements that make it even more versatile. The input sensitivity of each of the four channels is adjustable from a few millivolts to over 1V, so you plug in a range of input signals from a microphone to a line level signal from a CD player etc. A headphone amplifier circuit is included for monitoring purposes. A three stage EQ makes this is a very versatile mixer that will operate from 12VDC, 45mA. Kit includes case, PCB with overlay and all electronic components.

Short Circuits III Kit - Guitar Practice Amp
KJ-8092 £5.00 plus postage & packing
This low cost amplifier allows you to practice your guitar without annoying the neighbours. It has a guitar type input socket, small speaker and volume.



- Kit supplied with PCB, speaker, socket and electronic components.
- 12VDC power required.
- PCB: 105 x 60mm

Instructions NOT included. See KJ-8093 £0.70 for individual instructions or full colour project book BJ-8505 £4.25

Short Circuits III Kit - Guitar Link
KJ-8090 £4.50 plus postage & packing
Play the guitar without the need of a guitar amplifier and speakers. This neat pre-amplifier allows you to connect to virtually any amplifier including your home hi-fi.

- Kit includes PCB, 6.5mm sockets and electronic components.
- 12VDC power required.
- PCB: 105 x 60mm

Instructions NOT included. See KJ-8091 £0.70 for individual instructions or full colour project book BJ-8505 £4.25

Short Circuits III Kit - Guitar Distortion Unit
KJ-8102 £5.00 plus postage & packing
Distortion is popular to many guitarists. It can make the music sound quite different. Project includes PCB, 6.5mm sockets and electrical components. 12VDC power required.

PCB: 105 x 60mm

Instructions NOT included. See KJ-8103 £0.70 for individual instructions or full colour project book BJ-8505 £4.25

STEREO HEADPHONE DISTRIBUTION AMPLIFIER

KC-5417 £10.25 plus postage & packing
Enables you to drive up to two stereo headphones from any line level (1volt peak to peak) input. The circuit features a facility to drive headphones with impedances from about 8-600 ohms. The Jaycar kit comes with all specified board components and quality fibreglass tinned PCB.

- Power Supply to Suit: KC-5418 £6.00
- PC board size: 134 x 103mm

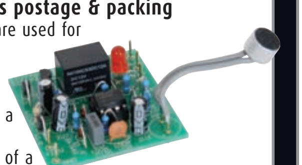
"THE CHAMP" AUDIO AMPLIFIER

KC-5152 £2.50 plus postage & packing
This tiny module uses the LM386 audio IC, and will deliver 0.5W into 8 ohms from a 9 volt supply making it ideal for all those basic audio projects. It features variable gain, will happily run from 4-12VDC and is smaller than a 9 volt battery, allowing it to fit into the tightest of spaces.

- PCB and all electronic components included.
- PCB: 46 x 26mm

"MINIVOX" VOICE OPERATED RELAY

KC-5172 £4.75 plus postage & packing
Voice operated relays are used for 'hands free' radio communications and some PA applications etc. Instead of pushing a button, this device is activated by the sound of a voice. This tiny kit fits in the tightest spaces and has almost no turn-on delay. 12VDC @ 35mA required. Kit is supplied with PCB electret mic, and all specified components.



PCB: 47 x 44mm

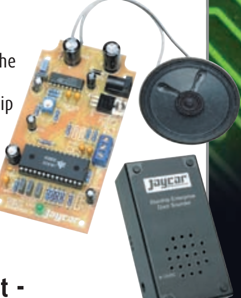
45 SECOND VOICE RECORDER MODULE

KC-5454 £12.75 plus postage & packing
This kit has been improved and can now be set up easily to record two, four or eight different messages for random-access playback or a single message for 'tape mode' playback. Also, it now provides cleaner and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9-14V DC. Supplied with silk screened and solder masked PCB and all electronic components.

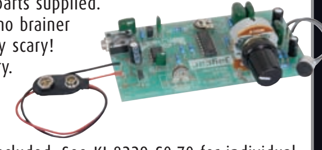
PCB: 120 x 58mm

SCI-FI

Starship Enterprise Door Sound Emulator
KC-5423 £11.75 plus postage & packing
FOR ALL YOU TREKKIE FANS!
This easy to build kit emulates the unique sound of a cabin door opening or closing on the Starship Enterprise. The sound can be triggered by switch contacts or even fitted to automatic doors. Comes with PCB with overlay, speaker, case and all specified components.
9-12VDC regulated.



Short Circuits II Project - Sound Like a Dalek
KJ-8228 £7.00 plus postage & packing
This project will change your voice into that metallic sounding robot voice so familiar in the space adventure movies. PCB and parts supplied. Connect it to the no brainer amp and get really scary! Requires 9V battery.



PCB: 102 x 57mm

Instructions NOT included. See KJ-8229 £0.70 for individual instructions or full colour project book BJ-8504 £3.75

Short Circuits II Project - Knight Rider Light Scanner
KJ-8236 £6.00 plus postage & packing
Now you can make the light scanner that goes on the bonnet of that famous car. Looks fantastic in all sorts of places! PCB and all parts supplied. Requires 9V battery.

PCB: 102 x 55mm

Instructions NOT included. See KJ-8237 £0.70 for individual instructions or full colour project book BJ-8504 £3.75

LED Sabre with Light & Sound Effects
GT-3520 £5.75 plus postage & packing

new

Challenge your friends in an intergalactic battle and bring balance to the force. Extremely light and durable, made of tough acrylic to take all the knocks of travelling around the galaxy at light speed. Sound and light effects.

Size: 710(L) x 48(Dia)mm

NEW KIT OF THE MONTH

Remote Control Digital Timer Kit
KC-5496 £11.25 plus postage & packing
Remote-controlled digital timer with a bright 20mm-high 7-segment red LED display. It can count up or down from one second to 100 hours in 1-second increments. Its timing period can either be set and controlled using the remote control or it can be automatically controlled via external trigger/reset inputs. An internal relay and buzzer activate when the unit times out. The relay contacts can be used to switch devices rated up to 30VDC or 24VAC and the project can be powered from a plugpack or a battery. Short form kit only - you'll need to add your own universal remote, power supply and enclosure.

- 9-12VDC @300mA
- PCB and components

NEW TO JAYCAR

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Minimum order £10	

Note: Products are despatched from Australia, so local customs duty & taxes may apply.
- **All pricing in Pounds Sterling**
- **Minimum order £10**

Prices valid until 31/10/2010

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FAX:	**+61 2 8832 3118***
EMAIL:	**techstore@jaycarelectronics.co.uk**
POST:	**P.O. Box 107, Rydalmere NSW 2116 Australia**

***Australian Eastern Standard Time**
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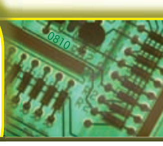

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NEWS

A roundup of the latest Everyday News from the world of electronics

Learning to shoot in 3D By Barry Fox

SONY has been running free 'masterclasses' in 3D programme production.

The first classes, given to 300 cinematographers at Sony Pictures studios in Culver City, California, were followed by two weeks of tuition for 250 European professionals at the BBC TV Centre in White City. The object of the exercise is to help TV and film producers make better 3D material, and so encourage consumers to buy 3D TVs – rather than get headaches and stick with 2D.

Buzz Hays, executive Stereoscopic 3D producer at Sony and chief instructor at the 3D Technology Centre, ran the courses.

'Two years ago at *CES* we heard that 3D would be here in three to five years,' he said. 'This past year we heard it's here.'

'Making 3D is easy, but making it good is hard,' Hays said. 'It's not the technology that's at fault with uncomfortable 3D, it's the execution of the content.

'We wanted to make sure game developers weren't creating situations – because it's happening in real time – that were creating eye strain and eye fatigue.'

Although Sony TVs now incorporate 2D-to-3D conversion circuitry, Hays is adamant that the results are nowhere near as good as material shot in 3D.

'Conversion requires human intervention because no matter how smart computers are, if I'm sitting down here and seeing 40 faces, how do I know which one is in front?

How does anybody know? I have to make a judgment call on that. With a computer trying to make that judgment for me, how does it know?'

'Automated conversion by a TV is what I refer to as 'not 3D.' It's not 3D, it's not 2D – it's somewhere in the middle.'

At the London classes, Hays showed graphic examples of the kind of 3D mistakes that can make audiences feel ill.

'There are obvious mistakes, like shooting on a boat in rough seas or using small handheld cameras or putting a camera on a bike that is bouncing down a track.'

Less obvious is shooting extreme depth, which makes the viewer's eyes diverge – look out and sideways – whereas eyes normally converge, that is, look inwards.

'I warn you this will hurt like heck' he said before screening a test shot which showed objects at wildly different depths apart. 'Producers make the cardinal mistake of falling in love with the image on a monitor. Then when it is shown on a large screen viewers' eyes diverge.'

Hays also challenged assumed wisdom: 'People say you can't do fast cuts in 3D. But that's wrong. There is a problem with fast cutting if the shots show different depths and the eyes' convergence keeps changing. But if you smooth out the depth differences between shots it's much easier to watch fast cuts. And you can adjust convergence at the post-production stage.'

Hays also warned that 10% of the population cannot see 3D at all. Others have put the percentage of people who cannot see 3D in the way that the producer intended it as high as 50%.

Gyroscopes for gaming and navigation

MENTION the word 'gyroscope' and many of us will think of the popular spinning top toys that seem to defy gravity, balancing at improbable angles on the end of a piece of string. They are strangely intriguing devices, with no obvious use beyond entertainment. However, their curious response to being rotated has made them vital devices for sensing motion – not linear motion, for that you need an accelerometer, but angular motion.

Originally, gyro sensors were complicated, expensive, cumbersome mechanical devices, much used by the military for guiding torpedoes, missiles and rockets. Now though, they have become cheap electronic components, so cheap that one leading manufacturer – InvenSense, Inc – sells them for as little as 3US$ in bulk, and a still reasonable 15$US if you just want one.

In fact, InvenSense don't just sell you one gyro, but three, all fitted into a single tiny package. The gyros are not the traditional spinning mass type, but use a type of tuning fork that is sensitive to rotation. InvenSense's ITG-3200 is designed with three independent MEMS (Microelectromechanical systems) gyro structures on a single substrate. It also integrates three high-resolution 16-bit analogue-to-digital converters for accurate rotation detection, as well as low-pass filters, an embedded temperature sensor, and a Fast Mode I2C serial interface, which all help eliminate the need for signal processing and many external components.

The three gyros are mounted perpendicular to each other in an XYZ configuration, which provides detection of any possible combination of angular movements.

So, how is this useful and who uses it? There is a fast growing market in two key areas – navigation and gaming. Smart mobile phones are now being sold with built in gyros that work with GPS and digital maps, ensuring that when you turn a corner, the system knows in which direction you are pointing.

Gaming input devices, such as the popular Wii from Nintendo allow you to play virtual tennis, golf or a whole host of other games by providing real-time feedback on the orientation as well as position of your virtual tennis racket. Details at: **www.invensense.com**.

Banker turns to teaching mathematics and science online

IF last month's *Circuit Surgery* tested your mathematical skills beyond what you are comfortable with, then there is good news in the unlikely form of an ex-hedge fund analyst – Salman Khan from the US.

The 'Khan Academy' is a collection of mathematics and science video clips that can be accessed for free over the Internet. The majority of the clips deal with mathematics and its applications, but there are plans to greatly widen the subjects to include not just science, but also disciplines as diverse as English and history.

Just a few minutes 'with' Khan as he talks you through an apparently complex problem reveals that he is a naturally gifted teacher, and is wonderfully enthusiastic about his project. He never sounds tired, bored or lacking in motivation, despite the fact that he has posted an incredible 1700 videos. He works hard and charges nothing for the material. In an interview with the *San Francisco Chronicle* he succinctly explained the driving force behind his work: 'With so little effort on my own part, I can empower an unlimited amount of people for all time. I can't imagine a better use of my time.'

So, what does he cover and how does the Academy work? Khan really does start from scratch, and assumes no prior mathematical knowledge. Video 1 in the Arithmetic section kicks off with 'Simple addition', and he really means 'simple' – he starts with '1+1'! From there, you can follow topics all the way up to university level, taking in mathematical areas useful to *EPE* readers such as calculus, including differential equations and integration similar to the ones we touched on last month.

The teaching style is unusual, simple, but effective. He avoids the 'teacher in front of a blackboard' approach. All you see is the equivalent of a piece of 'electronic paper' showing his workings, coupled with the narration. It feels like having someone sat next to you, carefully talking you through exercises.

Khan's free teaching videos are available at: **www.youtube.com**; his own website at: **www.khanacademy.org** and via another interesting Internet educational initiative called 'Curriki', available at: **www.curriki.org**. Curriki was set up by Scott McNealy, a co-founder of Sun Microsystems, the company that pioneered Unix workstations and the Java software platform.

McNealy views traditional educational textbooks, particularly in mathematical and science subjects, as old-fashioned and unnecessary – as well as being massively over-priced. He brings together high-quality, free-to-view material, such as Khan's, and makes it available over the Internet.

Even if you are not interested in learning or using mathematics, the chances are good that you know someone who might need help, and this is a collection of tutorials that should be at the top of everyone's list of useful – and free – web resources.

Trackpads for desktop computers

THERE are remarkably few ways for humans to interact with computers. Take away the keyboard and mouse and you'd find most computers would sit in splendid isolation. True, we are starting to see more and more touch-sensitive screens, but for selecting a point on the screen, it is the mouse which rules supreme – well almost. Although most laptop computers can easily use a mouse, the usual input technology – part from the keyboard of course – is a trackpad, a touch-sensitive plate that responds in varying ways to the motion of finger tips, typically using a combination of capacitive and conductive sensing circuits.

Initially, trackpads were plain-and-simple sensing devices, which detected a finger's position. However, in recent years, extra sophistication has been added that allows the trackpads to tell if one, two, three or even four fingers are interacting with the pad, and to use this information for increasingly sophisticated commands.

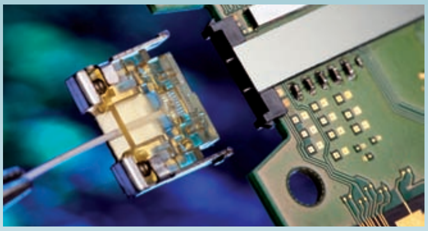
Instead of simply positioning or moving a cursor, trackpads can now move pages up and down, or zoom in /out of a window. Some even allow you to twist and rotate images – all with a quick finger/hand gesture combination.

Track pads were originally thought of as merely a neat way to incorporate mouse functions into a laptop and avoid having a clumsy mouse and wire connection. However, trackpads have now acquired so many useful functions that they are now being looked as worthwhile input devices in their own right, and not just a 'second-rate' solution for computing on the go.

Apple have recently brought out a trackpad (somewhat over-egging the cake, by calling it the 'Magic Trackpad') specifically designed for desktop computers. It uses Bluetooth technology, so avoids cable clutter, and recognises clicks; one, two and three-finger gestures, as well as thumb/index finger motion.

You can swipe through pages, as if you were reading a book or magazine, and it even has 'inertia' technology that gives this motion a natural feel. Last, using the new trackpad does not mean ditching a mouse – you can use it in conjunction with a mouse (and keyboard), providing you have enough hands of course.

Speed of light interface



CHIP giant Intel has announced an important advance in the quest to use light beams to replace the use of electrons to carry data in and around computers. The company has developed a research prototype representing the world's first silicon-based optical data connection with integrated lasers. The link can move data over longer distances and many times faster than today's copper technology; up to 50 gigabits of data per second. This is the equivalent to an entire HD movie being transmitted each second.

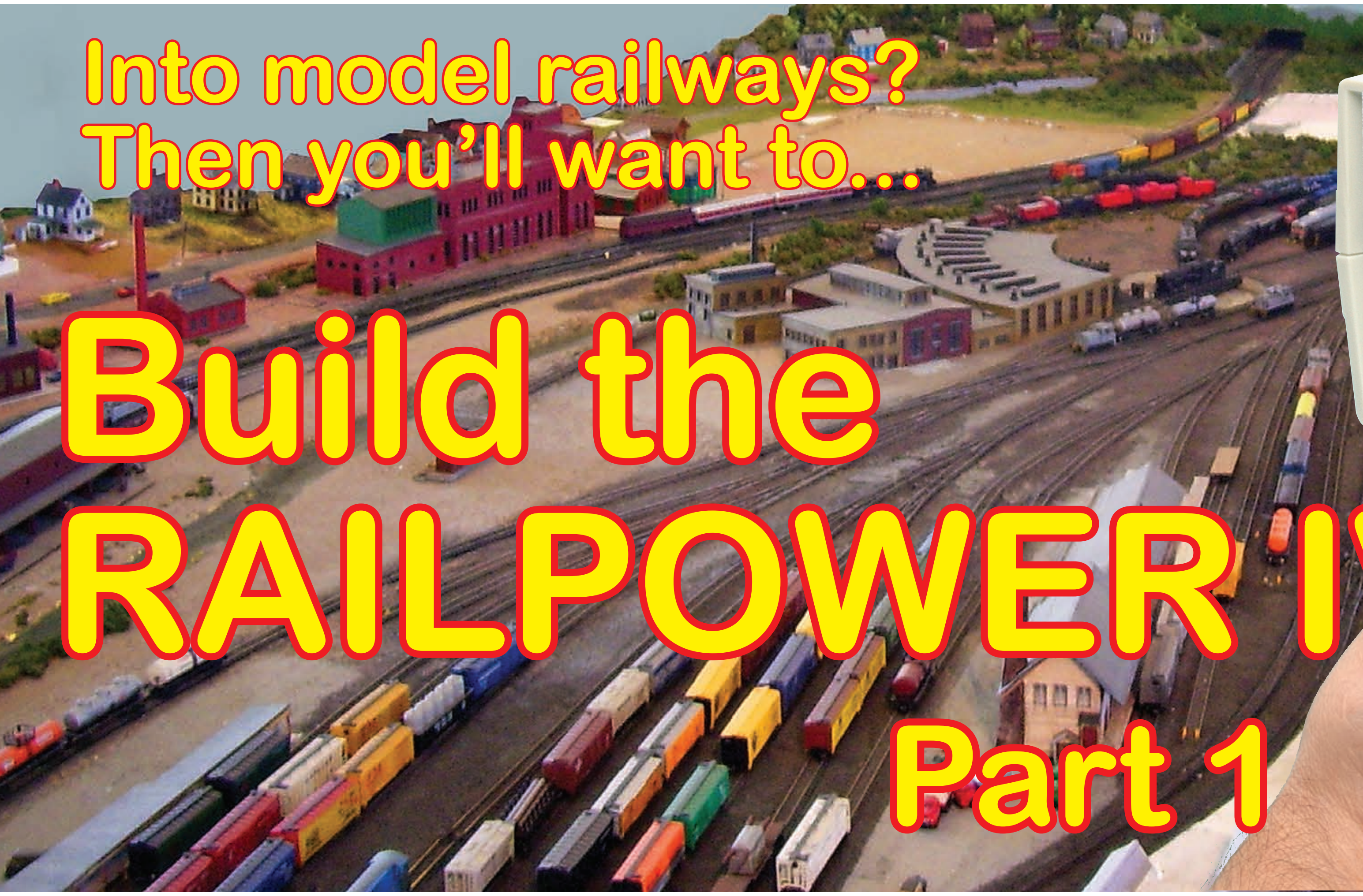
Today, computer components are connected to each other using copper cables or tracks on circuit boards. Due to the signal degradation that comes with using metals such as copper to transmit data, these cables have a limited maximum length. This limits the design of computers, forcing processors, memory and other components to be placed just inches from each other. Intel's research achievement is another step toward replacing these connections with extremely thin and light optical fibers that can transfer much more data over far longer distances.

'Silicon photonics' will have applications across the computing industry. For example, at these data rates one could imagine a wall-sized 3D display for home entertainment and video conferencing, with a resolution so high that the actors or family members appear to be in the room with you. Tomorrow's data-center or supercomputer may see components spread throughout a building or even an entire campus, communicating with each other at high speed, as opposed to being confined by heavy copper cables with limited capacity and reach.

The transmitter chip is composed of four lasers, whose light beams each travel into an optical modulator that encodes data onto them at 12.5Gbps. The four beams are then combined and output to a single optical fiber for a total data rate of 50Gbps. At the other end of the link, the receiver chip separates the four optical beams and directs them into photo detectors, which convert data back into electrical signals.

Both chips are assembled using low-cost manufacturing techniques familiar to the semiconductor industry. Intel researchers are already working to increase the data rate by scaling the modulator speed as well as increasing the number of lasers per chip, providing a path to future terabit/s optical links – rates fast enough to transfer a copy of the entire contents of a typical laptop in one second.

This research is separate from Intel's Light Peak technology, though both are components of Intel's overall I/O strategy. Light Peak is an effort to bring a multi-protocol 10Gbps optical connection to Intel client platforms for nearer-term applications. Silicon photonics research aims to use silicon integration to bring dramatic cost reductions, reach tera-scale data rates, and bring optical communications to an even broader set of high-volume applications.



Into model railways?
Then you'll want to...

Build the RAILPOWER IV

Part 1

This ultra-high performance model train controller features infrared remote control. We believe it's the best build-it-yourself train controller ever published!

ONCE upon a time, model trains were every kid's dream hobby – but nowadays, they are much more likely to be the province of their dads and grand-dads.

To a true model railway enthusiast, realism of rolling stock, track layout, scenery and train operation is paramount – and it's not hard to spend up to a thousand pounds or more on a good loco. (Some model railway 'widows' insist it's the spender that's loco!)

Many model railway enthusiasts have permanent setups occupying vast areas of their homes – inside and out! We've heard of model railway enthusiasts who have bought a new house simply on the basis that it lends itself to their hobby. Bedrooms? bathrooms? kitchen?.. who cares?.. as long as there is room for his 'trains'!

One thing that every enthusiast understands is that the old-fashioned rheostat-type controller is 'dead', and simply not up to the task. To achieve that realism we mentioned earlier, they must have a high-performance train controller, one that can vary the speed, direction and be able to simulate the inertia of a full-size train. And one with switchmode (pulse power) operation for really good low speed control.

Finally, infrared remote control (so you can direct operations from anywhere on your layout) is practically essential – and not just on larger layouts.

Railpower Mk. IV

Our latest Railpower train controller (actually the fourth one we've published in 20+ years) is, we believe, outstanding. The completely new design, based on a PIC microcontroller, provides all those wanted features and more.

Those who have had a chance to try it out reckon it's right up there with the best commercial controllers costing hundreds of pounds more.

This latest Railpower design is packed full of features to enable a locomotive to be driven smoothly over its full speed range.

While all of the control features can be accessed from a handheld remote, there is also a large knob on the front panel to control the speed – for those who like to feel 'in control'! There are also four pushbuttons on the front panel to adjust all the settings, as well as providing direction, stop and inertia on/off.

Features

- Pulse power for extra smooth low-speed operation
- Back-EMF detection for speed regulation
- Infrared remote control
- Front panel speed control
- Speed setting displayed as bargraph and percentage value
- Actual speed bargraph display
- Adjustable simulated inertia with on/off control
- Adjustable braking (stop) inertia
- Forward and reverse lockout
- Indication of stop, direction, inertia and lockout
- Overload protection with visual and audible indication

Design by
JOHN CLARKE

Infrared remote control

A standard pre-programmed remote is used to access all the standard features such as speed, direction, braking (stop) and inertia on/off. And since we are using a standard remote control, we have allocated the standard buttons to control particular functions.

For example, the volume up and down buttons control the speed, the mute button is used for braking (stop), while the channel up and down buttons select forward or reverse, respectively.

Just like the real world, the direction of the locomotive cannot be changed if it is running above a certain speed (which we call the 'lockout' speed). So, if you want to change direction you have to slow down the locomotive before the Railpower IV will let you change the direction.

This prevents derailments, which can be catastrophic if you are using a locomotive (or two/three) ahead of a long train.

Using the Stop (mute) function brings the locomotive to a stop when pressed and lets the train return to its original speed setting when pressed again.

Just like in TV operation, if you have pressed the Stop (mute) button, pressing the Speed (volume up) button, returns the train to its original setting. However, if you have Stop pressed, you can also use the Volume Down button to reduce the speed setting while the train is stationary.

Inertia

Real trains have huge amounts of inertia. A big coal-drag or iron ore train may be 20,000 tonnes or more, and you can bet that when the driver calls for an increase in speed, nothing happens quickly. In fact, the driver of a real train must not apply full power quickly, otherwise the train couplings can be easily broken.

In the modelling situation, we wish to simulate that huge inertia so that changes in speed setting are not immediately reflected by a change in actual train speed. We can adjust the amount of simulated inertia over a wide range, to simulate the effect of a locomotive running in 'light engine' (ie, no carriages or wagons) to that large coal-drag we mentioned above.

Simulating train inertia adds greatly to the operation of model trains. Instead of trains accelerating like 'jack rabbits' or coming to a screeching halt (which

Specifications

Output voltage	16V to 17V pulse width modulated (PWM), in 819 steps up to 80% duty cycle
Output current	up to 6A
Pulse frequency	122Hz, 488Hz or 1953Hz
Speed setting display	60-step bargraph and percentage from 0-100%.
Actual speed display	60-step bargraph
Minimum speed setting	adjustable
Lockout speed setting	adjustable
Default speed setting	adjustable
Infrared remote codes	Philips RC5; TV, SAT1 and SAT2
Infrared remote range	8m (indoors)
Inertia adjustment	From 0-100 corresponding to about 1 to 100s (dependent on minimum and maximum settings)
Stop adjustment	From 0-100 corresponding to about 1 to 100s (dependent on minimum and maximum speed settings)
Back EMF Feedback control	Adjustable from 0 to 100 corresponding to no back-EMF control through to a maximum
Speed ramp rate	From 0 to 255 corresponding to the rate of speed setting change with remote control
Bi-colour LED	Shows track voltage and direction

would surely cause fatal injuries to passengers and a lot of rolling stock damage if duplicated in real life operation!) they move off slowly, or even ponderously, in the case of long freight trains.

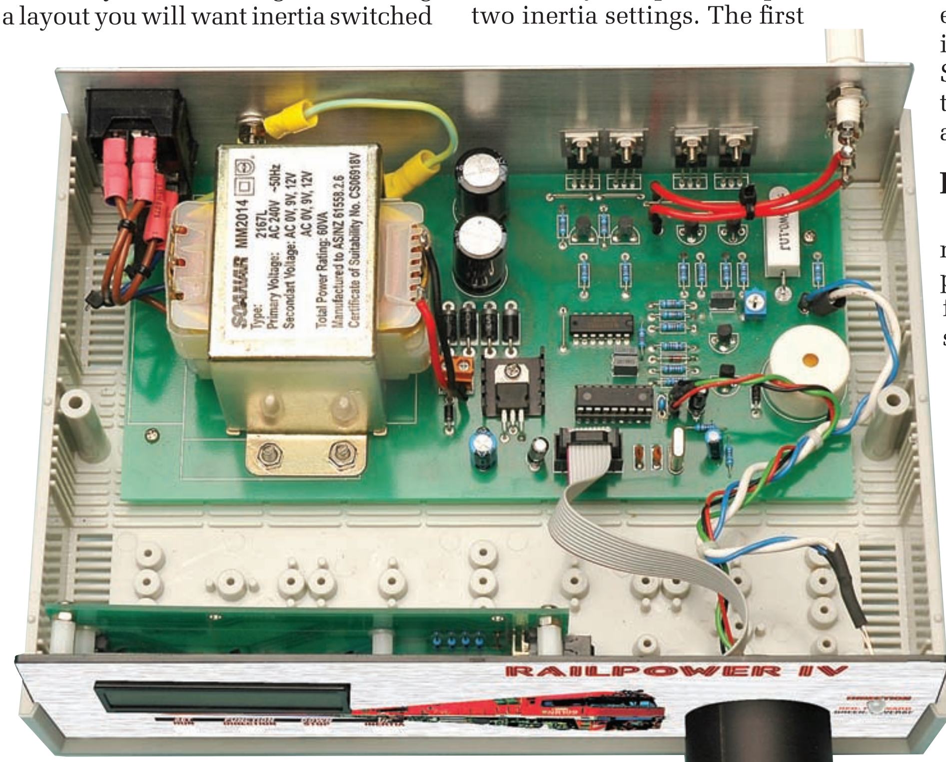
Inertia can be toggled on or off with the remote control's On/Off switch (normally used to turn the TV on or off).

When you are running a train along a layout you will want inertia switched on, but when shunting or other delicate manoeuvring, you will probably want to switch the inertia off. When inertia is set to off, the locomotive motor responds almost instantly to speed setting changes.

Run and braking inertia

Actually, Railpower IV provides for two inertia settings. The first is for running a train, giving a very gradual increase or decrease in train speed in response to a given setting. The second is braking inertia, which means that the train can be brought to a stop smoothly and quickly when you press the Stop button.

However, if you have the Inertia switched off, there is no braking inertia and the train will come to an immediate jarring stop if you press the Stop button. As we mentioned before, these and all the other settings can be adjusted via the front panel buttons.



Given the amazing control that the Railpower IV gives the model train enthusiast, there is certainly not much to it, thanks to the power of the PIC16F88-I/P. It is built on two PC boards (one for the display) and mounts in a 260mm × 85mm × 180mm ABS case. It offers both local and infrared control

Pulse power

Having realistic inertia counts for nothing if the train controller cannot provide smooth reliable acceleration from a standing start. To provide smooth low-speed control and very smooth starts, you cannot use smooth DC or unfiltered DC operation.

It just will not work properly, and the result can be a locomotive which is stalled until you wind up the voltage to such a level that when the loco finally does move, it takes off like a startled rabbit and may even spin its driving wheels furiously.

The only way to ensure reliable low speed operation, apart from having clean track and regularly cleaned locomotive wheels, is to use what railway modellers refer to as 'pulse power' and what electronics people call switchmode or pulse width modulation (PWM).

Whatever it is called, it involves driving the locomotive with high amplitude

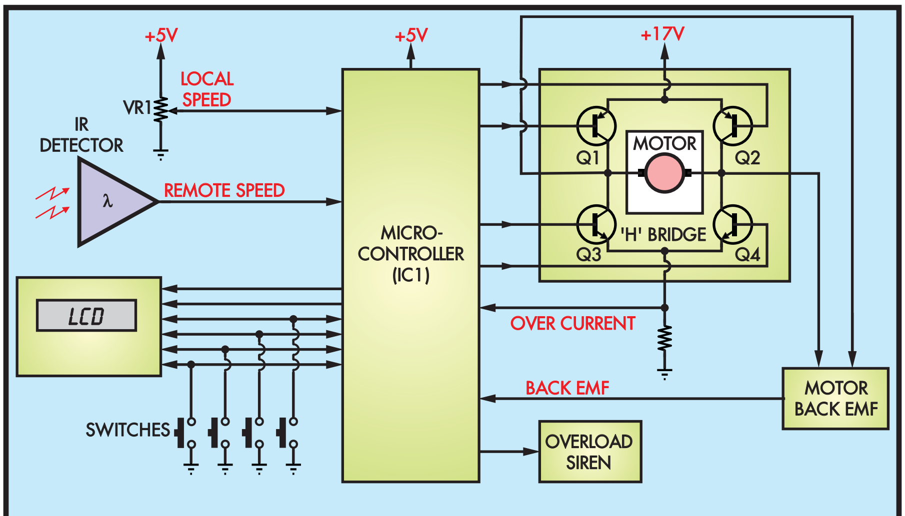


Fig.1: the block diagram of the Railpower IV belies just how powerful this new train controller is. It's by far the best we have published and is only made possible through the use of a PIC microcontroller.

(typically 16V to 17V) pulses, which easily overcome track/wheel contact resistance and motor stiction (static friction) to ensure smooth starting and low speed running.

Speed regulation

The other way to ensure good low speed operation is to monitor the back-EMF of the motor. This is the voltage which opposes current flow through the motor due to the applied voltage.

In permanent magnet DC motors, as used in most model locomotives, back-EMF is directly proportional to speed.

Therefore, if we want the controller to maintain a set speed, we monitor back-EMF to provide a feedback signal to the circuit. It works very well.

Liquid crystal display

A 2-line liquid crystal display (LCD) indicates train speed and speed settings, as well as direction, stop and whether inertia is switched on or off. The train and speed settings are shown as horizontal bargraphs. The speed setting is also shown as a percentage from 0 to 100%. The lower bargraph shows the speed setting while the upper bargraph shows the actual train speed.

If the Railpower IV is overloaded, or the output is shorted, the top line of the LCD shows 'OVER' in place of the direction arrow, padlock icon (lockout), S and I indicators. An internal overload siren also sounds and power to the motor is stopped until the current overload is ended.

As mentioned, you can change all the settings with the front panel switches below the LCD panel. We will discuss those details next month.

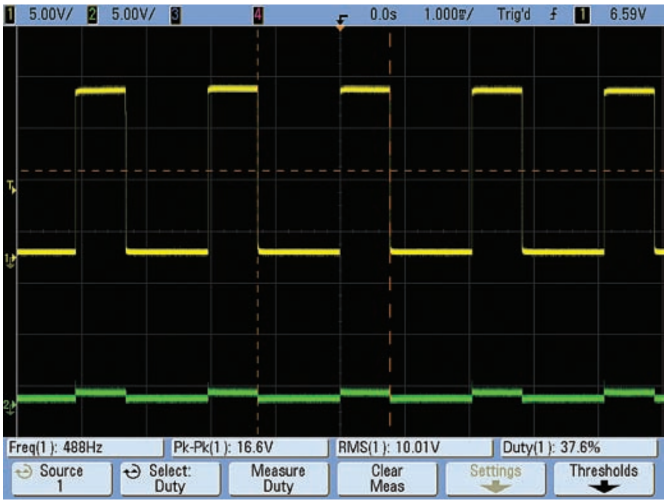
The Railpower IV is presented in a large instrument case that houses the power transformer and circuitry. At the rear panel is the mains input and power switch and two terminals for connection to the track layout.

Circuit details

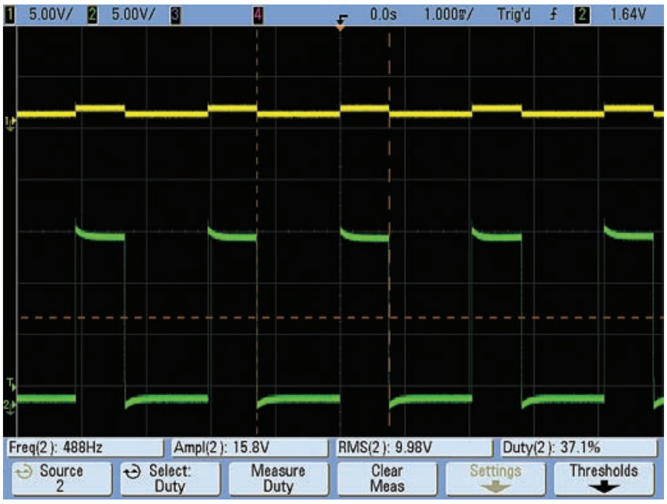
A block diagram of the circuit is shown in Fig.1. It comprises the PIC microcontroller, which drives the LCD module, the H-bridge and overload siren. It also monitors signals from the infrared detector, the front panel switches, the over-current monitor and the back-EMF from the locomotive's motor.

The H-bridge drive circuit comprises four power Darlington transistors – Q1, Q2, Q3 and Q4 – which drive the motor (ie, locomotive) in switchmode as well as providing for forward or reverse operation.

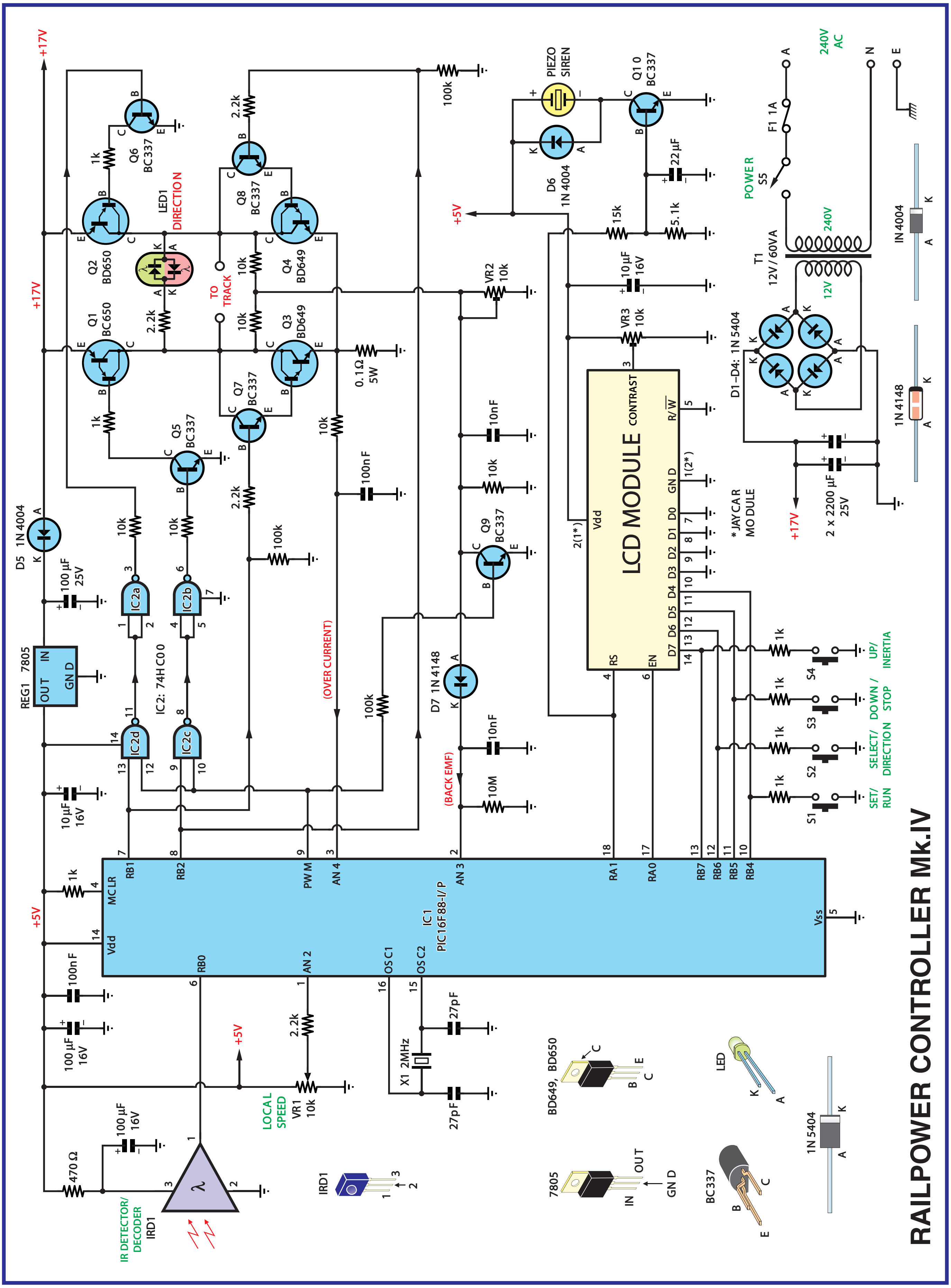
For forward operation, Q1 and Q4 are switched on while Q2 and Q3 are switched off, to provide current in one



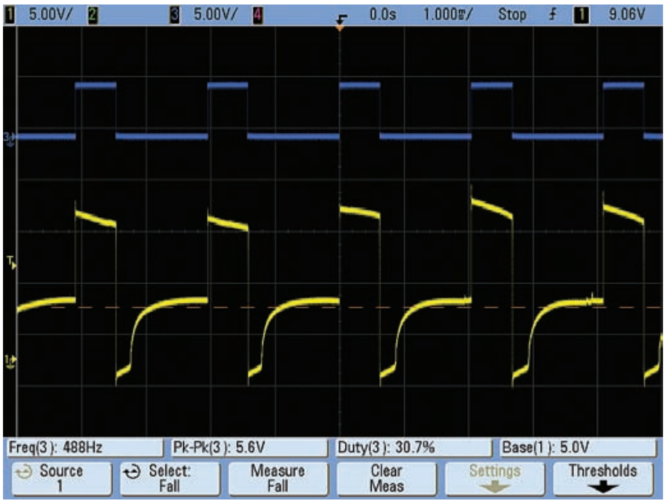
Railpower operation driving a 470Ω resistor load. The top (yellow) trace is the junction of Q2/Q4 Darlington transistors, with Q2 being driven by the pulse signal. The bottom (green) trace is the junction of Q1/Q3, with Q3 being turned fully on. The small amplitude signal is mostly due to the voltage across the 0.1Ω 5W sensing resistor. The voltage across the motor (load) is the difference between the two signals.



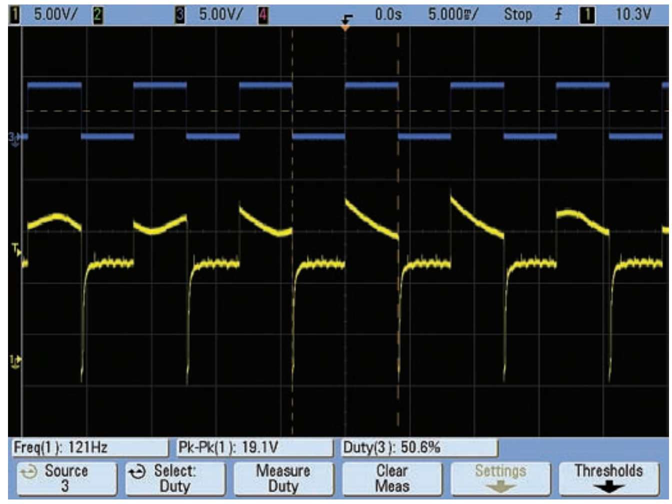
This shot shows operation in the reverse direction. The top trace now shows a small amplitude signal with Q4 being turned fully on. The green trace shows Q1 being fed by the pulse signal. Note that both these scope shots show operation at 488Hz. Operation at the other frequencies of 122Hz and 1953Hz is similar.



RAILPOWER CONTROLLER Mk.IV



Railpower operation with a 12V permanent magnet motor. The top (blue) trace is the pulse (PWM) signal from IC2a which drives Q6 and Q2. The yellow trace shows the, voltage across the motor for a duty cycle of 30.7%. The back-EMF is the shelf part of the waveform corresponding to the low (off) times of the blue trace. In this case, the back-EMF is being measured by the horizontal cursor at 5V.



The same set-up as previously, but with a PWM frequency of 122Hz instead of 488Hz. The PWM duty cycle is 50%. In this case, the motor back-EMF is much higher, as would be expected with a high average driving voltage. In general, permanent magnet motors work better with lower pulse frequencies as their inductance has less effect. The uneven tops of the yellow trace are caused by 100Hz ripple on the 17V supply.

direction through the motor. Similarly, for reverse operation, Q2 and Q3 are switched on while Q1 and Q4 are switched off, providing current through the motor in the opposite direction.

At the same time, to provide the switch-mode operation (pulse power), Q1 is pulsed on and off at the preset rate (which may be 122Hz, 488Hz or 1953Hz) while Q4 is switched fully on (forward operation). Similarly, for reverse operation, Q2 is pulsed (at, for example) 122Hz, while Q3 is fully on.

A common sensing resistor, connected to the emitters (E) of Q3 and Q4 is used to monitor the current drain by the locomotive motor. We also monitor the motor when all transistors are off (ie, in the off periods of the switchmode signal) to determine the back-EMF of the motor and thereby its loading.

The full circuit diagram is shown in Fig.2. IC1 is a PIC16F88-I/P microcontroller. We are using its PWM (pulse width modulation) output at pin 9 and three analogue inputs to monitor the signals for over-current, back-EMF and the front panel speed potentiometer VR1.

The remaining input/output pins are used to monitor the infrared detector (IRD1), drive the LCD panel and piezo siren, and to monitor the four front panel switches.

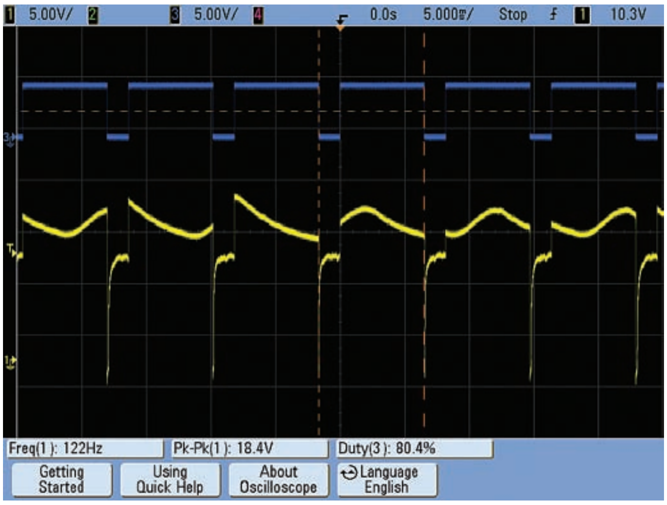
H-bridge drive

IC2, a 74HC00 quad CMOS NAND gate and transistors Q1 to Q8 provide the H-bridge drive. This is somewhat more complicated than the simplified schematic of Fig.1, but you can see the similarity, with Q1 to Q4 being the heavy-duty Darlington power transistors. The high gain of these transistors is further boosted by Q5 to Q8.

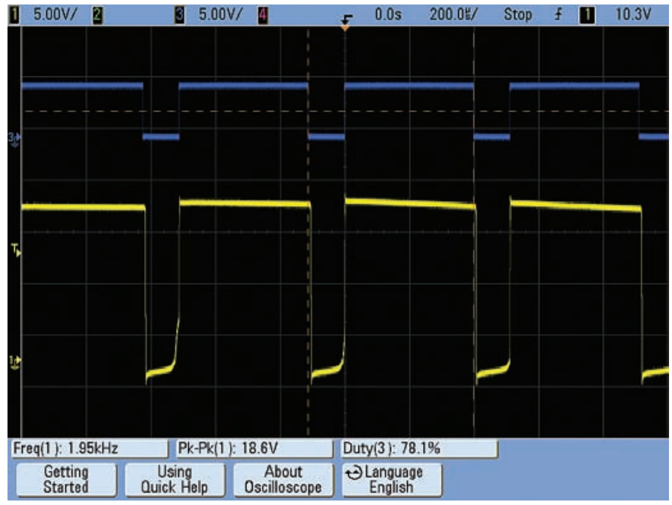
The H-bridge drive circuit works as follows. Outputs RB1 and RB2 (pins 7 and 8) of IC1 drive NAND

Fig.2 (opposite): the circuit of the Railpower IV consists mainly of a PIC microcontroller and an H-bridge motor driver. The PIC also drives the LCD module directly.
With the exception of the local speed control and direction LED, everything is mounted on two PC boards. You have the choice of complete remote control (with a range of up to 8m indoors) or 'local' control with a speed pot and pushbuttons on the front panel.

Just to whet your appetites, here's the Railpower IV mainboard, which we will fully describe next month. Almost everything is mounted on this or the display board. The connections to this board are (clockwise from top right) 230V power from the mains input socket/fuse/switch, earth connection to back panel, output to terminals on back panel, track direction LED and local speed potentiometer (both on front panel).



This scope shot shows the Railpower operating at full power, with a pulse duty cycle of 80.4% and pulse frequency of 122Hz. The back-EMF, measured in the off periods, can be seen to be quite high, as the motor will be running at full speed.



Operation at the highest frequency of 1953Hz and with a duty cycle of close to 80% gives an apparently smoother waveform, since motor hash and power supply ripple are not evident. However, typical motors will run more slowly at this high pulse rate.

gates IC2d and IC2c, which are then inverted by IC2a and IC2b. These gates drive transistors Q5 and Q6 via 10kΩ resistors to their bases (B).

Outputs RB1 and RB2 also drive the bases of Q7 and Q8, respectively. These outputs (ie, RB1 and RB2) work in complementary fashion so that when RB1 is high, RB2 is low and vice versa. So, when RB1 is high, Q6 turns on Q2 and Q7 turns on Q3, giving the forward operation described previously. Similarly, when RB2 is high, Q5 turns on Q1 and Q8 turns on Q4, giving reverse operation.

So, RB1 selects forward operation, while RB2 selects reverse operation. At the same time, the PWM output of IC1 (pin 9) is gated through IC2d and IC2c, depending on the state of RB1 and RB2. So the PWM signal provides switchmode operation of Q1 and Q2, as previously described.

Note that as well as providing considerable current gain in the H-bridge circuit, the eight transistors also provide voltage level translation between the flea-power 5V signals from the micro to the 17V pulses to the locomotive motor.

Over-current monitoring

The 0.1Ω 5W resistor provides motor current sensing. The voltage across this resistor is fed to the AN4 input (pin 3) of IC1 via a 10kΩ resistor, while a 100nF capacitor filters the signal, preventing transients from being detected.

IC1 converts the voltage to a digital value and switches off power to the motor should the current exceed 6A. A current of 6A corresponds to 0.6V at AN4. Power is switched off by taking both the RB1 and RB2 outputs low, so that none of the transistors are on to drive the motor.

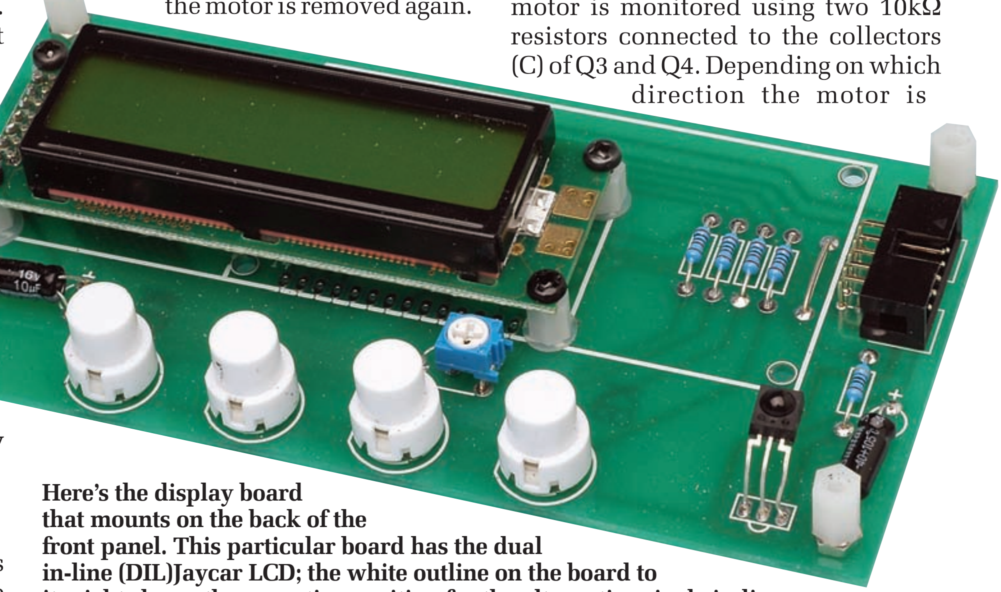
But IC1 restores motor drive momentarily every 0.2s and if the sensed current is below the 6A, the motor is again allowed to run. If current is still over 6A, then the power to the motor is removed again.

At the same time as an overload is detected, output RA1 (pin 18) drives transistor Q10 to sound the piezo siren, which has an in-built oscillator.

The RA1 output is also used to send data to the LCD module. To avoid turning on transistor Q10 with the data signal, a 22μF capacitor at its base filters out the short periods of high data signal from RA1. So, when we want to drive the transistor, we must apply the high signal from RA1 for about 100ms before Q10 will switch on.

Back-EMF monitoring

Back-EMF from the locomotive motor is monitored using two 10kΩ resistors connected to the collectors (C) of Q3 and Q4. Depending on which direction the motor is



Here's the display board that mounts on the back of the front panel. This particular board has the dual in-line (DIL)Jaycar LCD; the white outline on the board to its right shows the mounting position for the alternative single in-line (SIL) pinning displays.

Parts List – Railpower IV

1 PC board, 773 (Cont), size 217mm × 102mm
1 PC board, 774 (Disp), size 141mm × 71mm
Boards will be available from the *EPE PCB Service* next month
1 12V 60VA mains transformer (2167L type) (T1)
1 2-line 16-character dual in-line (DIL) LCD module (Jaycar QP-5516), or alternative single in-line (SIL) version
1 front panel label, 243mm × 76mm
1 plastic instrument case, 260mm × 190mm × 80mm
1 aluminium rear panel, 243mm × 76mm × 1.5mm
1 chassis-mount male IEC connector with fuse and switch
1 M205 1A fuse (F1)
1 IEC 3-core 240V AC mains lead, with 3-pin plug
1 universal infrared remote control (see text)
1 PC mount piezo buzzer
1 DIP18-pin IC socket for IC1
1 DIP14-pin socket cut to suit LCD connector
1 14-pin DIL header strip for LCD module or 1 SIL 14-pin header strip for alternative LCD module, with 2.54mm pin spacing
1 3-way header strip with 2.54mm pin spacings
1 mini heatsink 19mm × 19mm × 9.5mm
1 2MHz crystal (X1)
1 2-way PC-mount screw terminals, 5.08mm pin spacing
2 binding posts
1 knob to suit VR1
4 SPST PC-mount tactile snap-action switches (S1-S4)
2 10-pin IDC line sockets
1 10-pin IDC vertical header
1 10-pin IDC right angled header
1 200mm length of 10-way IDC cable
1 200mm length of 7.5A green/yellow mains wire
1 100mm length of 7.5A brown mains wire
1 150mm length of black hookup wire
1 150mm length of red hookup wire
1 150mm length of green hookup wire
1 150mm length of 0.8mm tinned copper wire
5 4.8mm female insulated spade connectors
1 6.4mm female insulated spade connector
1 chassis mount quick connect spade terminal (6.4mm)
2 5.3mm ID eyelet quick connector
6 100mm cable ties
4 M3 × 10mm screws
4 TO-220 insulating kits (silicone washer and bush)
5 M3 nuts
5 M4 × 10mm screws
5 M4 nuts
3 4mm star washers
6 No.4 self-tapping screws
4 M3 tapped × 6mm nylon spacers
4 M3 tapped × 12mm spacers
4 3mm nylon washers
12 M3 × 6mm screws
4 M3 × 6mm countersunk screws
4 PC stakes

Semiconductors
1 PIC16F88-I/P preprogrammed microcontroller (IC1)
1 74HC00 quad NAND gate (IC2)
1 infrared detector/decoder (IRD1)
2 BD650 *PNP* Darlington power transistors (Q1,Q2)
2 BD649 *NPN* Darlington power transistors (Q3,Q4)
6 BC337 *NPN* transistors (Q5-Q10)
4 1N5404 3A rectifier diodes (D1-D4)
2 1N4004 1A rectifier diodes (D5,D6)
1 1N4148 signal diode (D7)
1 dual colour LED with two leads (LED1)

Capacitors
2 2200µF 25V PC radial electrolytic
1 100µF 25V PC radial electrolytic
2 100µF 16V PC radial electrolytic
1 22µF 16V PC radial electrolytic
2 10µF 16V PC radial electrolytic
2 100nF MKT polyester
2 10nF MKT polyester
2 27pF ceramic

Resistors (0.25W 1%)

1 10MΩ	3 100kΩ	1 15kΩ	4 10kΩ
1 5.1kΩ	4 2.2kΩ	7 1kΩ	1 470Ω

1 0.1Ω 5W
2 10kΩ horizontal trimpots (VR2,VR3)
1 10kΩ linear rotary potentiometer (VR1)

running, the back-EMF will come from the collector of Q3 or Q4, whichever transistor happens to be off at the time.

Note that the back-EMF signal will be attenuated by the 10kΩ resistor connecting to the transistor that happens to be on, but this does not matter as we need to further attenuate the signal with trimpot VR2 anyway. This is needed to limit the back-EMF signal so it is below the 5V maximum to the AN3 input (pin 2) for IC1.

However, there is a further condition to monitoring back-EMF and that is that it can only be done while the motor is not being energised, ie, in the times when the PWM signal from IC1 is off.

To that end, transistor Q9's base is switched by the PWM signal so that it is on when the PWM signal is high. This shunts the back-EMF signal to 0V so that we are only monitoring 'pure' back-EMF and not a mix of back-EMF and applied voltage.

The signal from Q9 is fed via diode D7, filtered with a 10nF capacitor and passed to the AN3 input. Diode D7 prevents the voltage at AN3 dropping to zero each time Q9 switches on. A 10MΩ resistor discharges the 10nF capacitor over a 100ms period so the input can respond to a falling back-EMF signal.

IC1 converts the back-EMF signal to a 10-bit digital value, and this is used to modify the PWM signal to the motor. If the back-EMF is falling, the pulse width (duty cycle) is increased in order to maintain the motor speed. Similarly, if the back-EMF increases (maybe when going downhill) the pulse width is reduced.

Trimpot VR2 is adjusted to suit a range of locomotives that you might have on your layout.

Potentiometer VR1 is the front panel speed control. It varies the voltage to

At left is the rear of the Railpower IV case. It looks pretty spartan – but that's deliberate. All you have is the switched and fused IEC mains input on the right and the two binding post terminals on the left, which supply power to the track. Because the track polarity can be either way (as selected by the user) these are not colour coded. The bicolour LED on the front panel indicates direction.

the AN2 input (pin 1) between 0 and 5V. Again, this voltage is converted to a 10-bit digital value and sets the speed of the motor when the controller is set to 'local' (ie, front panel) control.

Switches and LCD drive

The four pushbutton switches S1 to S4 connect to the RB4 to RB7 lines for IC1. Normally, the RB4 to RB7 lines are set (by the software) as inputs, with internal pullup resistors. When a switch is pressed, the corresponding input is pulled to 0V and IC1 detects this event.

The same RB4 to RB7 lines also drive the LCD module, and to do this they are set as outputs. The 1kΩ resistors are included in series with the switches to prevent the RB4 to RB7 lines becoming shorted to ground (0V) when a switch is pressed and when the lines are set as outputs. Driving the LCD occurs only momentarily at a slow repeat rate, and so for most of the time, the RB4 to RB7 lines are ready to monitor the switches.

The LCD data is sent in 4-bit wide words. The DB0 to DB3 data lines are not used. The RA1 output (pin 18) from IC1 drives the register select input to the LCD, while the RA0 line (pin 17) provides the enable signal. The display contrast is set with trimpot VR3. Note that the supply pin numbering is different for the dual in-line (DIL) and alternative single in-line (SIL) modules.

Infrared decoding

IRD1 detects the infrared signal from the handheld remote. This is encoded as bursts of 38kHz signal. The IR detector converts each burst as low (0V) and high (5V) in the absence of 38kHz. The decoded signal is sent to the RB0 input (pin 6) of IC1. IC1's software further decodes the signal sent by the IR remote and it will only accept encoding that is part of the Philips RC5 code.

This encoding is set on your handheld remote when you select a Philips or an affiliated company's brand of appliance. The software within IC1 will decode RC5 code for a TV, Satellite 1 and Satellite 2.

This means that you could use three separate Railpower controllers with their own IR remotes on the one layout, in conjunction with block switching. Furthermore, an additional Railpower could be employed with local (ie, non IR remote) to give four controllers on a large layout.

The Philips RC5 code for infrared transmission (also used with Marantz, Grundig and Loewe equipment) comprises 2-start bits and 1-toggle bit. The toggle bit alternates high and low on successive same key presses.

The code includes five system address bits and six command bits for a total of 14 bits. It uses bi-phase encoding with a high-to-low transition equal to a low signal and a low-to-high transition equal to a high signal. Each bit is transmitted at a 1.778ms rate. The entire code is 24.889ms in length, and the code is repeated every 113.778ms.

IC1 operates at 2MHz using crystal X1. This frequency was chosen because it allowed the PWM frequency to be as low as 122Hz with 10-bit resolution. The crystal also provides an accurate source of timing so that the infrared RC5 code can be decoded at the correct rate.

Power supply

The Railpower uses a 12V AC 60VA transformer to drive a bridge rectifier comprising four 3A diodes. The rectifier output is filtered with two 2200µF capacitors to give about 17V DC (depending on the mains input voltage).

This feeds the H-bridge driver for the motor. The 17V DC is also applied via diode D5 to 5V regulator REG1, which supplies IC1 and the rest of the circuit.

Software

The software files are available for download via the *EPE* Library site, accessed via **www.epemag.com**. Preprogrammed PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

Next month, we will complete the description of the Railpower with all the construction details and the set-up procedure.

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	3	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	15kΩ	brown green orange brown	brown green black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	1	5.1kΩ	green brown red brown	green brown black brown brown
❑	4	2.2kΩ	red red red brown	red red black brown brown
❑	7	1kΩ	brown black red brown	brown black black brown brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown

Foregone Conclusion

TechnoTalk

Mark Nelson

In an ideal world the blameless should not lose out, but that's not an inevitable conclusion, especially in consumer electronics. Having right on your side may give you a warm feeling, but that's little consolation if you can't use the equipment you have bought. Mark Nelson reports on a skirmish that legitimate citizens look set to lose.

The dictionary defines a foregone conclusion as a decision made before the evidence for it is known. Right now a technical discussion is taking place where the facts are both indisputable and yet will almost inevitably be ignored. Thousands, perhaps millions of people will be penalised, even though both the law and natural justice are on their side. Outrageous? Probably. Does it matter? I'll let you be the judge.

Radio spectrum under threat…

The rather melodramatic headline of 'Radio spectrum under threat' is a campaign document from the radio Society of Great Britain (RSGB). Their argument is that a vast number of non-compliant power line adapters (PLAs) in people's homes are polluting the airwaves, affecting reception of weaker radio stations. The RSGB is pursuing the communications watchdog OFCOM to take effective action to protect the HF (shortwave) spectrum from interference by power line devices.

So, is losing shortwave reception a big deal? Who has right on their side? What are PLAs and how do you know if you have a dodgy one? And if you do, does this make you a criminal?

… Or storm in a teacup?

We live in a changing world and the days when people listened regularly to shortwave stations are largely over, in the Western world at least. FM and digital radio dominate most people's listening habits, with television and the Internet equally important sources of news and entertainment. HF radio (the spectrum from 3MHz to 30MHz) still has significance for amateur radio enthusiasts, but even among these this is declining. All the same, interference to the airwaves is illegal, whether intentional or not and that's what the RSGB believes that the current attitudes of the UK and European regulators toward the roll-out of power line technology is a direct and real threat to the future viability of the HF spectrum.

Of course, HF radio has many users beyond amateur radio and international public broadcasting, for instance long-range aeronautical and oceanic communications as well as defence ministries. However, OFCOM states it has not received complaints from these users. The 150 or so complaints it receives in a year are all from radio enthusiasts, with a third of these now resolved by the apparatus suppliers. As a result, OFCOM has concluded that there does not at present appear to be significant public harm arising from this situation.

If the government watchdog sees the problem as no more than a storm in a teacup, the RSGB thinks otherwise, and has gone as far as instructing its lawyers to instigate a legal challenge to OFCOM's position. For its part, OFCOM has now commissioned an independent report by consultants. Until this work has been completed the RSGB has decided to defer the question of legal action. Meanwhile, it is still raising money for its Spectrum Defence fund (details at **http://www.rsgb.org/SpectrumDefence**).

Power line technology

So what are power line adapters? PLAs provide home networking ('Ethernet everywhere') without cabling: in effect, WiFi without wires. They avoid the need to flood your home or office with wireless and provide the same connectivity throughout your premises by sending signals along mains wiring, using small plug-in adapters.

If you extend your broadband around the home using BT Fusion you will have PLAs as part of that system, but there are many other products that work in the same way. Most carry broadband, but some extend just your telephone line or distribute audio and video signals around the house.

Like WiFi, PLAs work with low power wireless signals, but instead of radiating over the airwaves, they channel the signal along your mains wiring. Unfortunately, mains wiring can operate as a transmitting aerial and there are regulations in place to limit the electromagnetic disturbance generated by electronic equipment of this kind, with special 'notch' filters to prevent interference on amateur radio bands. Not all equipment is compliant with these regulations, and so far there is no harmonised standard across the European Union.

Polluter pays?

Power line products sold in the UK are required to comply with the Electromagnetic Compatibility Regulations 2006 (the 'EMC Regulations'), but identifying compliant equipment is not easy. In particular, the CE mark is no guarantee of this. To its credit, BT is reportedly very helpful, removing the offending adapters when a complaint is made.

If you are on the receiving end of interference from these you should contact OFCOM's advisory team on 0300 123 3333 for further assistance. You can find some interesting technical papers on interference from power line devices at: **www.elmac.co.uk/papers01.htm** and some spirited arguments at: **www.mds975.co.uk/Content/amateur_radio_BPL_interference_02.html**.

Using an unapproved PLA puts you in an awkward position, but any legal action is most likely to be taken against the person who places these products on the market (usually the manufacturer or the importer). He is responsible for compliance and must ensure that equipment meets the essential requirements and does not produce excessive levels of electromagnetic disturbance. Failure to meet this obligation can be a criminal offence.

Technically, users of any equipment that interferes with radio reception (this even includes noisy compact fluorescent light bulbs!) is guilty of an offence under the Wireless Telegraphy Act 2006 and The Communications Act 2003. Both of these acts prohibit the use of any device that 'degrades, obstructs or repeatedly interrupts anything which is being broadcast or otherwise transmitted'.

Mutiny on the airwaves

History often repeats itself, and the present skirmish has an ominous precedent in the battle for 27MHz in the early 1980s. Although Citizens' Band radio is now a minority hobby in the UK, there was a massive craze for it thirty years ago. Even though CB was illegal here, dealers imported radios from the USA, with tens of thousands of users operating illegal American sets. Massive pressure was put on the government to introduce legal CB, with supporters even staging marches and public demonstrations.

Licensed users on 27MHz frequencies (hospital radiopaging systems and radio-control model aircraft and boat enthusiasts) were first irritated by interference from CB pirates and then enraged when the government capitulated to the 'breaker' fraternity and legitimised Citizens' Band on 27MHz. Existing users were forced to buy new equipment on different frequencies, with no compensation for this significant unwished-for outlay.

Harvest celebration?

'Vibration-powered generators replace AA, AAA batteries' is the headline on the Tech-On news website. Brother Industries Ltd of Japan has demonstrated battery-sized electronic generators intended for use in devices that do not constantly use power, such as TV remote controls and LED flashlights that do not consume more than 180mW.

"The new generator will semi-permanently eliminate the need to replace batteries and contribute to reducing the amount of wastes," Brother Industries said. When the generator, which the company calls a 'Vibration-powered Generating Battery', is used inside a remote control, you simply shake it to generate power.

Part 1: By JOHN CLARKE

LED Strobe and Tachometer

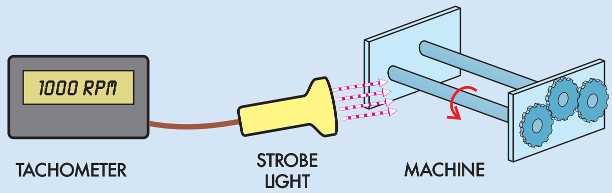
This versatile LED Strobe and Tachometer can be used to observe and measure the RPM of rotating machinery. It offers three different measurement methods and the readout is via a 2-line 16-character LCD module.

IT's easy to measure the speed of rotating machinery with this versatile project. It uses three different 'contactless' sensing methods, making it ideal for checking the RPM of objects such as rotating shafts, fans and model aircraft propellers.

In addition, the strobe feature allows rotating machinery to be effectively 'frozen' for close visual inspection. The strobe is based on a high-brightness white LED and can also be used to provide basic stroboscopic speed measurement. Alternatively, speed measurements can be made using either an infrared reflective optical pickup or a slotted disc/photo-interruptor pickup.

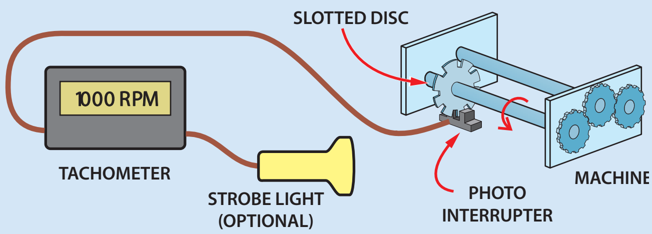
Strobing

Many people consider strobes as just a party effect, for use in discos and other venues. A typical disco strobe flashes at about four times a second and the strobing effect makes people appear to move in a jerky manner. That's because, in the dark, you only see each person's position when the



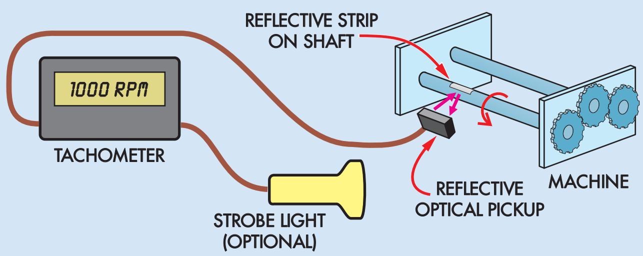
BASIC STROBOSCOPIC MEASUREMENT

Fig.1: using a strobe light to measure rotational speed. The strobe flash rate is manually adjusted until the machine appears to stop (see text) and the result read from the LCD.



TRIGGERED MEASUREMENT VIA SLOTTED DISC

Fig.2. A signal is sent to the 'tacho' from a sensor attached to the machine. The sensor can be an optical or Hall effect trigger that is interrupted by a rotating vane of magnet



TRIGGERED MEASUREMENT BY REFLECTION

Fig.3: this triggered measurement technique uses the tacho to count the pulses from a reflective optical pickup.

strobe flashes. The intermediate positions between flashes are not seen.

Strobing rotating machinery gives much the same effect, depending on the strobe frequency and the RPM of the rotating part. If the strobe is set to flash at a rate of once per revolution, then the rotation will appear to stop. The reason for this is simple – the machine will be in the same position each time the strobe flashes.

In fact, the effect is so convincing that it can be dangerous. **You must be alert to the fact that the machine must not be touched, since it is still actually moving and could cause serious injury.**

Other strobe effects also become apparent as the strobe frequency drifts out of step with the rotational frequency. For example, if the strobe flashes slightly faster than the rotational speed of the machine, then the machine will appear to rotate slowly backwards. Conversely, if the strobe flashes at a slightly slower rate than the rotational speed of the machine, the machine will appear to rotate slowly forward.

On a roll

One area where this is often apparent is in western movies, where the wheels of a stage coach initially appear to slowly rotate backwards and then stop while the stage coach is still moving. That happens because movies are shot at a rate of 24 frames/sec and this has the same effect on the wheels spokes as a strobe.

Initially, the wheel spokes are travelling too slowly to keep up with the strobing effect of the frame rate. Then, as the speed increases, the wheels appear to stop, before finally appearing to rotate forwards.

If we know the number of spokes in the wheel, we can even calculate its rotational speed when it appears to be stopped. For example, if the wheel has eight spokes, then its speed is equal to 1440 (the number of film frames per minute) divided by eight, or 180 RPM.

Similarly, the rotational speed of any machine can be measured by setting the strobe rate so that the motion appears to stop. Note, however, that you have to set it to the highest speed at which the machine appears to stop, since the same effect will also occur if strobing takes place at 1/2-speed or 1/3-speed, or 1/4-speed...

You also have to take into consideration the number of blades on a fan or propeller, or the number of marks on a shaft. For example, if there are two blades on a prop, then the prop will also appear to stop if strobed at twice the rotational speed. The solution to this problem is to place a single mark on the shaft or a propellor.

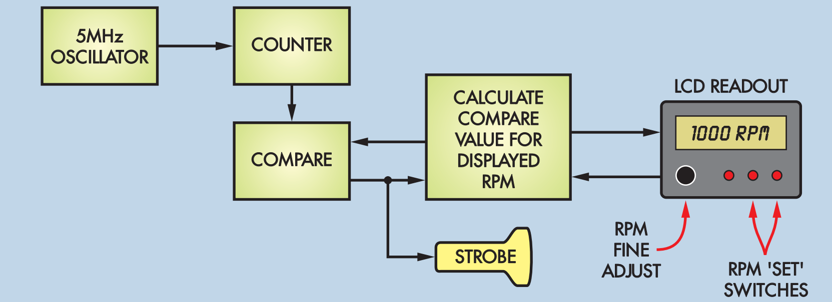
Fig.1 shows how the unit is used with a strobe to measure machine rotation. Note that if the strobe is set at twice the speed of the machine, there will appear to be two reference positions, each 180° apart. However, if the strobe is set at half rotational speed, there will be one reference position, but it will appear dimmer than when the strobe is set at the correct speed.

Photo-interruptor

Fig.2 shows another way to measure rotational speed. In this case, a trigger signal is sent to a tachometer from a sensor attached to the machine. This sensor could be either an optical trigger or Hall effect trigger that is interrupted by a rotating vane or magnet.

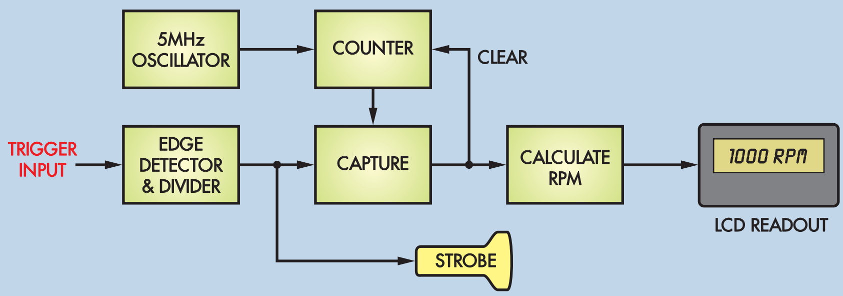
Warning!

Flashing lights, particularly in the lower frequency range from about 5Hz (300 RPM) and upward can induce seizures in people subject to photosensitive epilepsy. Flashing lights can also trigger a migraine attack. It is recommended that people prone to these effects avoid stroboscopic lights.



GENERATOR MODE OF OPERATION

Fig.4(a): this is the block diagram for the generator operating mode. The Up and Down 'RPM Set' switches and a fine adjust pot on the tachometer set the stroboscope's flash rate, while the LCD shows the corresponding reading in RPM,



TRIGGERED MODE OF OPERATION

Fig.4(b): the triggered mode of operation. In this mode, the counter counts the number of pulses from a 5MHz oscillator between each successive external trigger signal. This value is used to calculate the RPM, which is then displayed on the LCD.

Main Features

- RPM and frequency readout on LCD panel
- Generator or triggered strobe
- Can be triggered via slotted disc or reflective light
- Adjustable flash period
- Fine frequency adjustment in generator mode
- Wide frequency range
- 1 RPM resolution
- Divider options when triggering
- Triggering indicator
- Readout averaging

As the shaft rotates, it sends a series of pulses to the tachometer. The tachometer measures the frequency of these trigger signals and calculates the RPM for display on the LCD. As an option, the strobe can also be fired in synchronisation with the sensor.

The more rotating vanes used on the trigger, the greater the number of pulses generated for each rotation of the shaft. As a result, the unit can be set to a division ratio from 1 to 8, so that the displayed reading is correct. For example, if there are eight pulses per rotation, the division ratio is set to eight to get the correct reading.

A 0.5 divider has also been included. This can be used if the sensor is being triggered by a shaft that runs at half the speed of the shaft we want to measure.

For divisions from 2 to 8, you also have the option of firing the strobe on any one of the trigger signals. For example, if there are eight pulses per rotation, you can have the strobe fire either on the first pulse, the second pulse, the third pulse or on any other pulse up to the eighth pulse.

In addition, the pulse edge can be selected so that the strobe fires when the pulse signal goes high or when it goes low. Each of these triggering points will provide a different view of the machine – ie, the strobed position of the machine will vary.

Reflected IR

A third method of measuring the RPM of a rotating machine is shown in Fig.3. This is purely a non-contact method and relies on light reflection from the machine.

In some cases, a reflecting strip will have to be attached to the machine in order to get sufficient variation in the light reflection as the machine rotates. However, for rotating parts such as propeller or fan blades, the brightness variation should be sufficient without adding any reflective material.

In this measuring mode, an infrared (IR) light source is shone on to the machine and the resulting reflected light variations detected using an infrared photodiode. Using infrared prevents other light sources such as fluorescent lights from affecting the reading.

Strobe duration

When using a strobe, the duration of the flash determines just how much of the machine's rotation can be seen. Ideally, the flash should be as short as possible to prevent blurring of the strobed image (ie, we don't want the machine to move too much during the flash period).

Traditional strobes use xenon tubes, and these produce short, bright flashes that are ideal for strobing rotating machinery. However, this circuit uses a high-brightness white LED and its output is much lower than that from a xenon tube.

As a result, the flash period needs to be a compromise between brightness and the amount of movement that can be tolerated during the flash. And in case you're wondering, most white LEDs can be driven with very short pulse widths for use in strobe applications. If you are not convinced, read the 'Busting a Myth' panel in Part 2 next month.

For our LED strobe, the flash period can be set anywhere between 32μs and 6.5ms. A longer flash period gives a brighter light, but in practice, the period needs to be set to suit the application. The faster the machine spins, the lower we need to set the flash duration to prevent 'blurring' of the strobed machine.

For example, if the machine is rotating at around 5200 RPM, then we need to set the flash duration to just 32μs to limit the movement during this period

to 1°. However, at just 166 RPM, the flash duration can be increased to 1ms for 1° of movement.

As an alternative to a fixed flash period, there is an automatic mode which sets the flash period as a percentage of the measured RPM. This percentage can also be manually adjusted from 1% to 10% in 1% steps.

Note, however, that these percentage settings are not obtainable at very high or very low RPM values, due to the limited flash duration range (32μs to 6.5ms).

Operating modes

In order to carry out the different measurement techniques depicted in Fig.1 to Fig.3, the unit has two different operating modes: (1) generator and (2) triggered. Block diagram Fig.4(a) shows the generator mode of operation, while Fig.4(b) shows the triggered mode.

The generator mode is used for basic stroboscopic measurements and when this mode is selected, the unit directly drives the strobe light. In operation, the tachometer is initially adjusted using Up and Down pushbuttons and this sets the strobe rate and adjusts the corresponding RPM reading on the LCD.

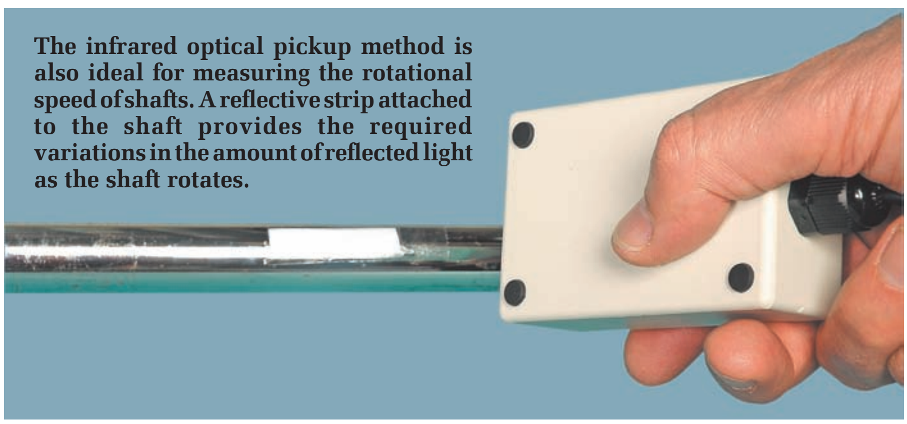
Each pushbutton alters the RPM setting in 100 RPM steps, while an adjacent knob provides for fine adjustment to 1 RPM resolution. The resulting LCD readout shows both the RPM (1 RPM resolution) and the frequency in Hz (0.01Hz resolution).

The alternative triggered mode is used to make the measurements depicted in Figs.2 and 3. In this mode, the tachometer is triggered by the pick-up sensor and the LCD shows the RPM and the frequency of the incoming trigger signal. The strobe light is optional and is also triggered by the pick-up sensor.

As discussed earlier, the sensor can be either a slotted disc and photo-interruptor assembly or an optical pick-up relying on reflected IR light. Note that, in this mode, the RPM reading cannot be adjusted manually and the tachometer reads the rotational speed according to the trigger pulses from the sensor.

If there is more than one trigger pulse per revolution, the strobe can be set to fire on any one of these by pressing either the Up or Down switch, to shift to the next trigger edge. In addition, the division ratio must be set to get the correct reading.

The strobe technique is used for measuring the speed of fan blades and for 'freezing' the motion while the machine is running. Alternatively, the infrared optical pickup method can be used for measuring the RPM of fans and model aircraft propellers, since the blades usually give good reflection variations.



The infrared optical pickup method is also ideal for measuring the rotational speed of shafts. A reflective strip attached to the shaft provides the required variations in the amount of reflected light as the shaft rotates.

How the tacho works

The way in which the tachometer works to measure the incoming RPM pulses is rather unconventional.

The traditional method of measuring frequency is to count the number of incoming pulses over a set period, usually one second. This is quite an acceptable method when the frequency is high and a lot of counts are obtained during the 1s period.

However, for RPM readings, the incoming frequency is usually relatively low and in most cases there just aren't enough counts over a 1s period to ensure sufficient accuracy. For example, at 1000 RPM, the incoming frequency would be just 16.66Hz (assuming one pulse per rev) and so we would read either 16Hz or 17Hz on a counter. After multiplying by 60 to convert to RPM, the display would show either 960 RPM or 1020 RPM.

In other words, there would be a 60 RPM uncertainty in the reading.

Of course, we could count the signal over 10s or even 100s to get 6 RPM or 0.6 RPM resolution. However, 10s is a long time to wait for a reading update and a machine can vary its RPM value quite significantly during that time. As for waiting 100s, forget it.

So how do we measure RPM with high resolution and a fast update time? Fig.4 shows how it's done.

For the triggered mode of operation, the tachometer utilises a 5MHz oscillator and a counter. The counter is configured to count the number of pulses from the 5MHz oscillator between each trigger signal.

For example, if the trigger signal has positive going edges that are 60ms apart, the counter will count to 300,000 between each pulse. The value

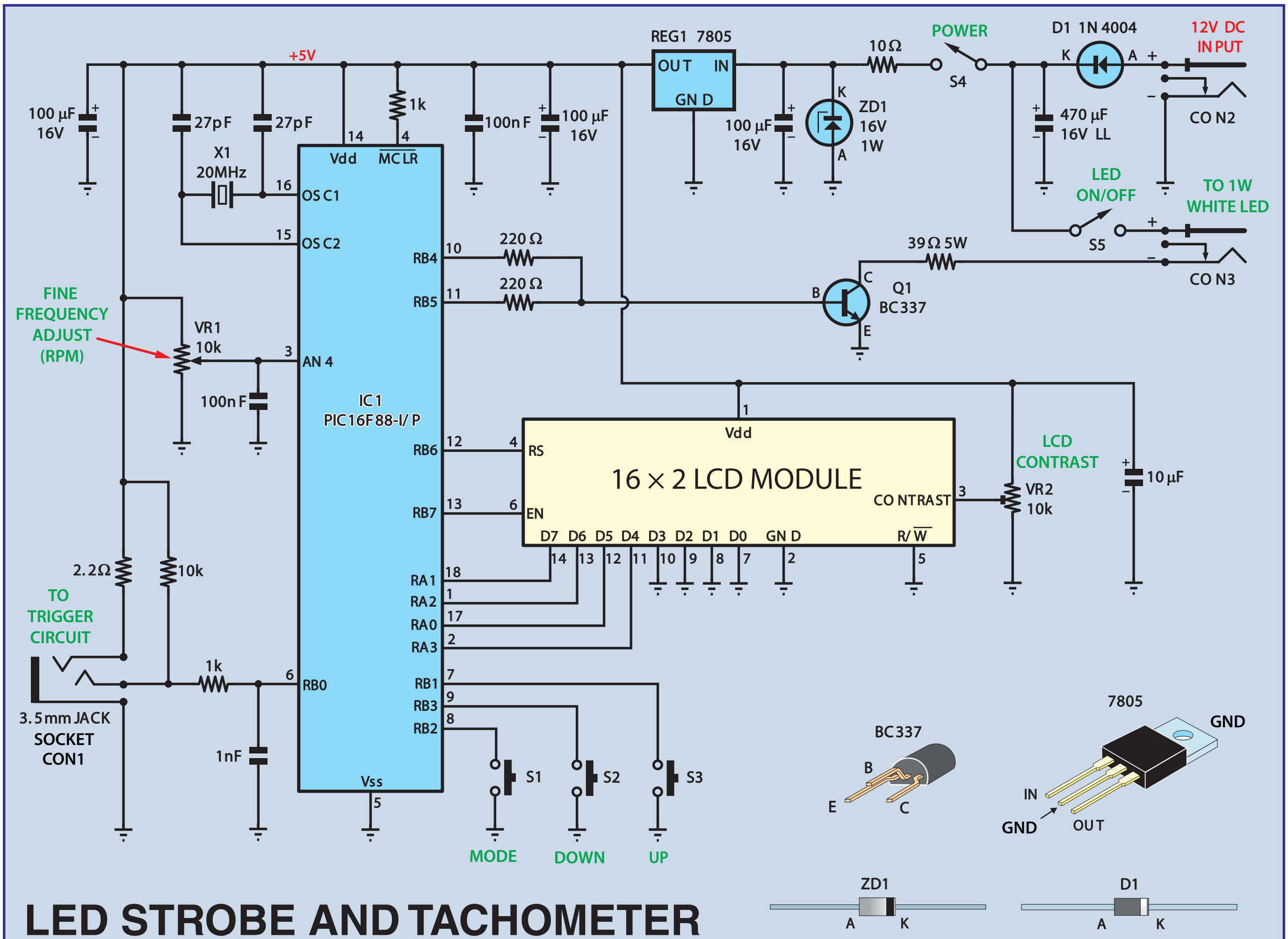


Fig.5: the circuit is based on a PIC16F88-I/P microcontroller (IC1) and a 16 × 2 LCD module. External trigger signals are applied to RB0 of IC1 via CON1, while RB4 and RB5 drive the white-LED strobe via transistor Q1. Power comes from an external 12V DC plugpack, with regulator REG1 providing a +5V supply rail for IC1 and the LCD.

of the count is then stored in a capture register, and the counter cleared so that it is ready for the next count.

A calculation is now made to derive the RPM. This simply involves dividing 300,000,000 (ie, the number of pulses from a 5MHz counter in one minute) by the register value. So, if the register value is 300,000, we get 1000 RPM.

Another calculation is made to derive the trigger frequency (50,000,000 divided by the register value).

This 1000 RPM calculation is made in just 60ms and has a resolution of 1 in 300,000, thus giving a display resolution of 1 RPM. This is significantly better than the method first described, which involved counting the 16.66Hz signal over a 1s period.

For the Generator mode, the operation is slightly different. The counter still counts the 5MHz signal, but in this case, a calculation is made to determine the value that the counter must reach to provide the required RPM value and strobe flash rate.

In this case, the calculation is 300,000,000 divided by the RPM setting. The calculated value is placed in the compare register and when the counter reaches this value, the strobe is fired. The counter is then reset and counts again to fire the strobe at the set RPM rate.

Circuit details

The full circuit details for the LED Strobe and Tachometer is shown in Fig.5. It consists of a PIC16F88-I/P microcontroller (IC1), a 16×2 LCD module and not much else.

So, in spite of the seemingly complex operation, the circuit itself is really very simple.

Most of the ‘smarts’ are hidden inside the micro, which is really the heart of the circuit. It runs at 20MHz using crystal X1 as its timebase, and this signal is also divided by four to derive the 5MHz oscillator that’s used for the RPM calculations.

In operation, IC1 monitors the external trigger signal (if one is present) at its RB0 input (pin 6), while RB1, RB3 and RB2 monitor the Up, Down and Mode switches respectively. In addition, IC1’s AN4 analogue port monitors the position of potentiometer VR1, which is used for fine RPM adjustments.

Note that RB1 to RB3 have internal pull-up resistors, so these inputs are normally pulled high to +5V. When a switch is closed, the associated input is pulled to 0V and so IC1 can detect this button press.

IC1 also directly drives the LCD module. RA0 to RA3 are the data outputs, while RB6 and RB7 drive the

register select and enable lines respectively. Trimpot VR2 sets the display contrast voltage.

When IC1 is operating in trigger mode, the signal applied to the RB0 input (pin 6) is used as the trigger for RPM measurements. This input is protected from excessive current using a 1kΩ series resistor, while a 1nF capacitor filters out any transient voltages to prevent false counts.

The external trigger circuit is connected via a 3.5mm jack socket and is fed with a +5V rail via the socket's ring terminal and a 2.2Ω resistor. The tip carries the external trigger signal and in the absence of signal, is pulled high via a 10kΩ pull-up resistor to the +5V rail.

Potentiometer VR1 is connected across the 5V supply and the wiper (moving contact) can deliver any voltage from 0V to 5V to the AN4 analogue input of IC1. IC1 converts this input voltage to a digital value to set the fine frequency adjustment over a 100 RPM range (but only when IC1 is operating in the generator mode).

Note that the operational range of VR1 has been deliberately restricted to 0.54V to 4.46V. This has been done because potentiometers often have abrupt resistance changes towards the ends of their travel. Using a 0.54V to 4.46V range ensures that the more linear section of the potentiometer is used.

Driving the strobe

IC1's RB4 and RB5 outputs provide the strobe (white LED) drive. Each output can source about 20mA into the base (B) of transistor Q1, which turns fully on each time a positive going pulse is applied.

Each time Q1 turns on, it also turns on a 1W high-brightness white LED, which is connected via CON3 (provided S5 is closed). Power for this LED is derived from the +12V supply rail, via reverse polarity protection diode D1. A 39Ω 5W series resistor limits the peak LED current to about 220mA. This resistor value was chosen so that even if the supply is 15V, the current will still be below the 350mA maximum for a 1W Luxeon LED.

Switch S5 allows the strobe LED to be manually switched on or off.

Power supply

Power for the circuit is derived from an external 12V DC plugpack and this is fed in via DC input socket CON2 and power switch S4. A 470μF 16V capacitor decouples the +12V supply, which is then fed to regulator REG1 and the strobe, while a 10Ω resistor and a 100μF capacitor provide additional decoupling for the supply to REG1. Zener diode ZD1 clamps the input to REG1 to 16V.

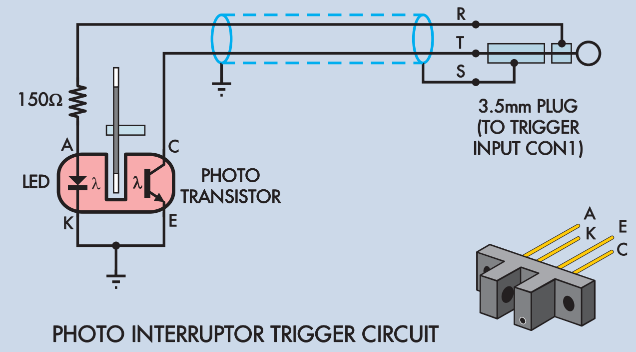
REG1's +5V output is used to supply both IC1 and the LCD. This rail is decoupled using a 100μF capacitor directly at the regulator's output, while an additional 100μF capacitor and a 100nF capacitor bypass the supply close to pin 14 of IC1. A 10μF capacitor provides additional bypassing for the supply at the LCD module.

Photo-interruptor circuit

Fig.6 shows the circuit for the photo-interruptor. It's very simple and is based on a slotted LED and phototransistor package, plus a vane assembly that rotates in the slot.

Power for the circuit comes from the +5V rail of the main circuit and is applied via the ring (R) terminal of a 3.5mm jack. A 150Ω resistor limits the LED current to around 20mA.

Fig.6: the photo-interruptor trigger circuit uses a slotted LED and phototransistor package, plus a rotating vane assembly attached to the machine.



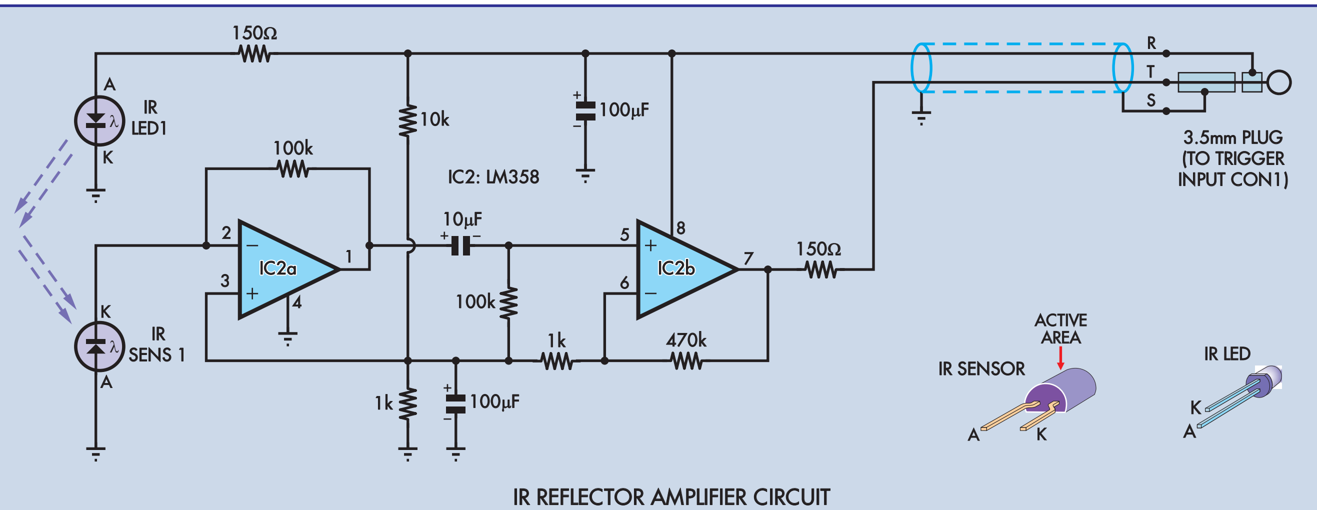


Fig.7: the IR reflector amplifier uses an IR LED and an infrared photodiode (IR SENS1) to pick up the reflected light pulses. The resulting current variations through IR SENS1 are then fed to current-to-voltage converter stage IC2a, which in turn drives amplifier stage IC2b. IC2b's output then drives the trigger input of the main tachometer unit.

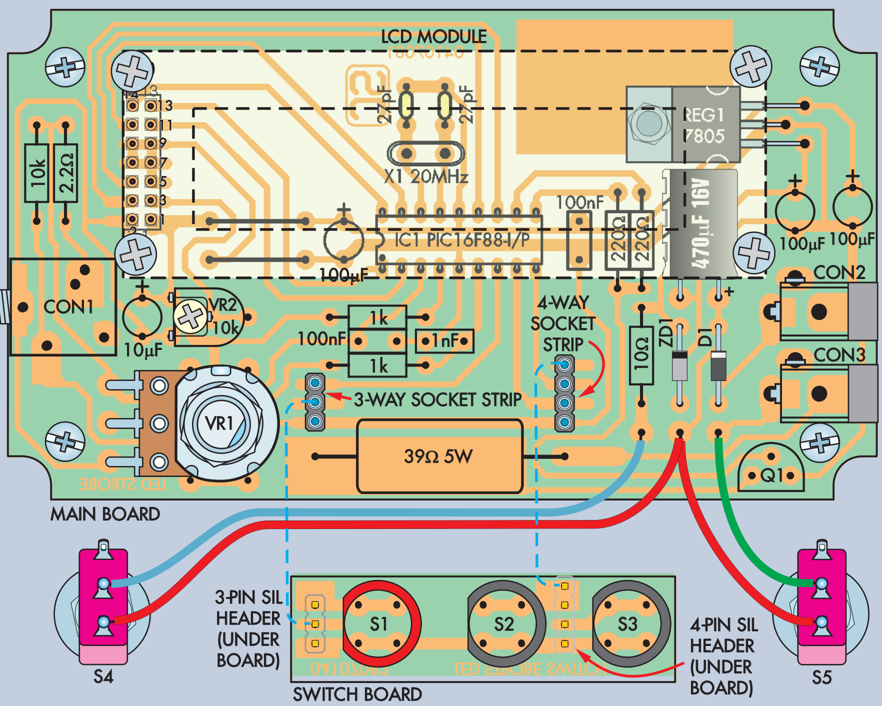
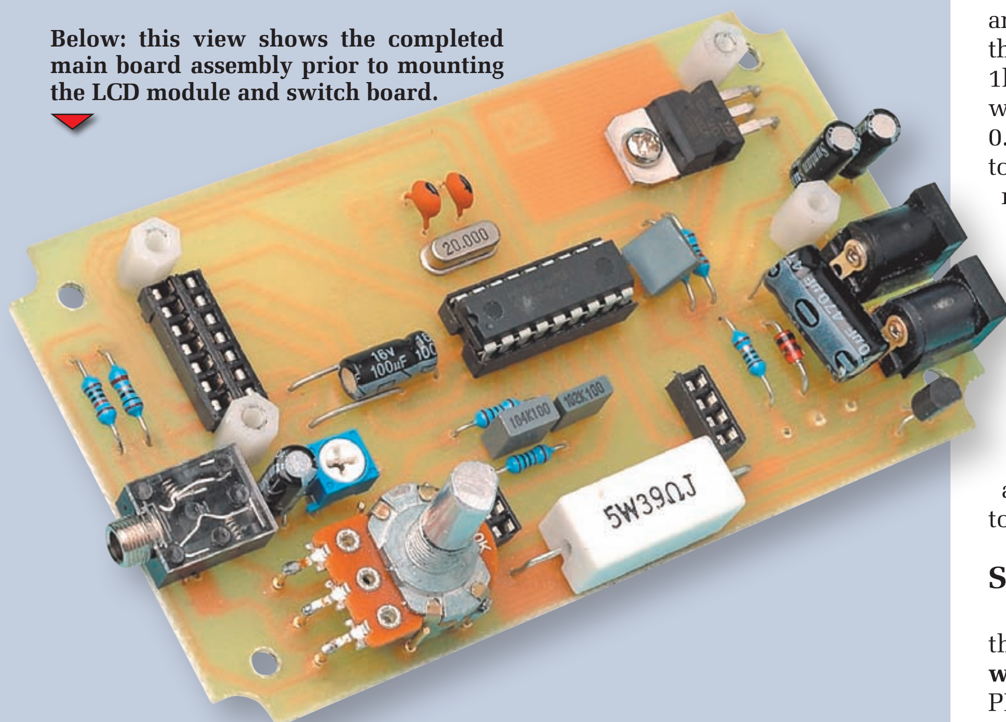


Fig.8: follow this layout diagram to install the parts on the main board and to assemble the small switch board. Take care with the orientation of the switches – they must all be installed with their flat sides to the left (see above).

Below: this view shows the completed main board assembly prior to mounting the LCD module and switch board.



With no vane in the slot, the phototransistor is illuminated by the LED. As a result, the phototransistor turns on and its collector (C) pulls pin 6 of microcontroller IC1 low via the tip connection of the jack socket. Conversely, when a vane passes through the slot, the phototransistor turns off and its collector is pulled to +5V via the 10kΩ pull-up resistor on the main circuit

IR reflector amplifier

The optical pick-up circuit is a bit more complicated – see Fig.7. It's based on an infrared LED (IRLED1), an infrared photodiode (IR SENS1) and an LM358 dual op amp (IC2). The infrared LED is powered via a 150Ω resistor from the +5V 3.5mm jack connector ring terminal and operates continuously whenever power is applied.

As mentioned previously, the photodiode is aimed at the rotating machine and the light is reflected back to the photodiode via a blade or a reflective strip attached to a shaft.

The infrared photodiode is connected to pin 2 of IC2a. This op amp is wired as an inverting amplifier and operates as a current-to-voltage converter. As shown, its non-inverting input (pin 3) is biased to about 0.5V by a voltage divider consisting of series 10kΩ and 1kΩ resistors connected across the 5V supply.

In operation, the current through the photodiode varies with the reflected light, and these current variations are converted to voltage variations at IC2a's pin 1 output. This signal is then AC-coupled to pin 5 of IC2b via a 10μF capacitor.

IC2b is connected as a non-inverting amplifier with a gain of 471, as set by the 470kΩ feedback resistor and the 1kΩ resistor at the inverting input. As with IC2a, IC2b is also biased to about 0.5V by the series 10kΩ and 1kΩ resistors across the 5V supply. The 100kΩ resistor between pin 5 and this 0.5V supply ensures that, in the absence of a signal from IC2a, IC2b's output normally sits at 0.5V.

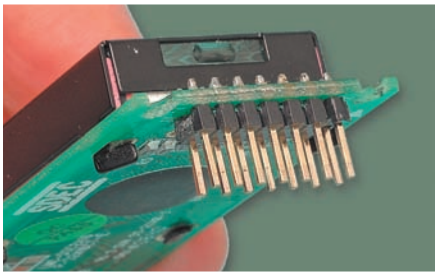
Each time sufficient light is reflected onto the infrared photodiode, IC2b amplifies the signal from IC2a and its output swings to about 4.5V. This signal is then fed to the tip of a 3.5mm jack plug via a 150Ω isolating resistor and applied to pin 6 (RB0) of IC1.

Software

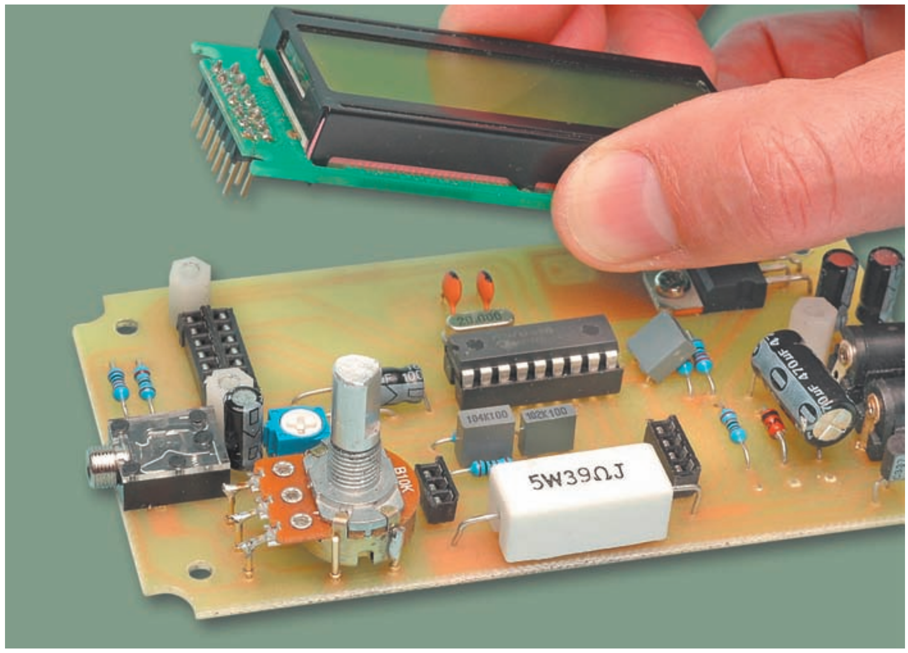
The software files are available via the *EPE* Library site, accessed via **www.epemag.com**. Pre-programmed PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

Construction

The main LED Strobe and Tachometer circuit is built on two PC boards: a main PC board coded 775 (size, 115mm × 65mm) and a switch PC board coded 776 (size, 52mm × 15mm).



The 14-way DIL header is installed from the underside of the LCD module and soldered to the pads on the top of the module's PC board.



Once the header has been attached, the LCD module is plugged into matching socket strips on the main board and secured to four M3 × 9mm nylon spacers.

This switch board plugs into the main board and the assembly is housed in a bulkhead style case with a clear lid.

Another two boards are used for the photo-interrupter and IR reflector amplifier circuits. The photo-interrupter board is coded 777 and measures 50mm × 25mm, while the IR reflector amplifier board is coded 778 and measures 53mm × 32mm.

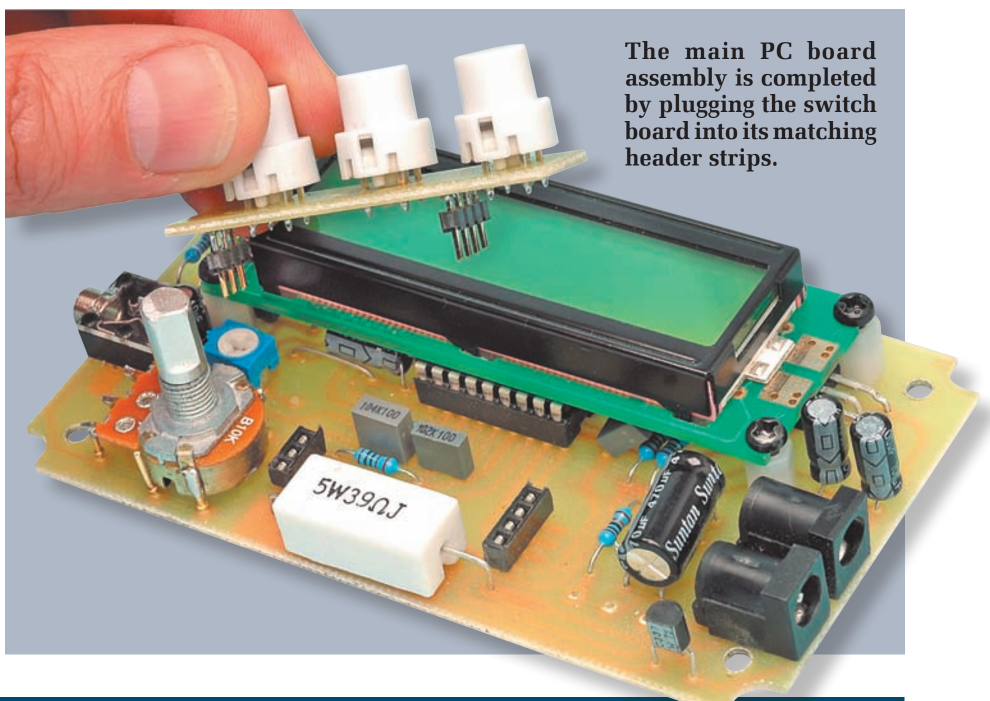
All these printed circuit boards will be available from the *EPE PCB Service*.

Main board assembly

Fig.8 shows the main board assembly details. Begin construction by checking the board for any defects. Check also that the hole sizes for the connectors and potentiometer VR2 are correct by test fitting these parts. Enlarge these holes so that the parts do fit, if necessary.

In addition, the holes for the four corner mounting screws, the LCD mounts and for REG1 must be 3mm in diameter. Check also that the PC board is cut and shaped (note the corner cutouts) so that it fits into the box.

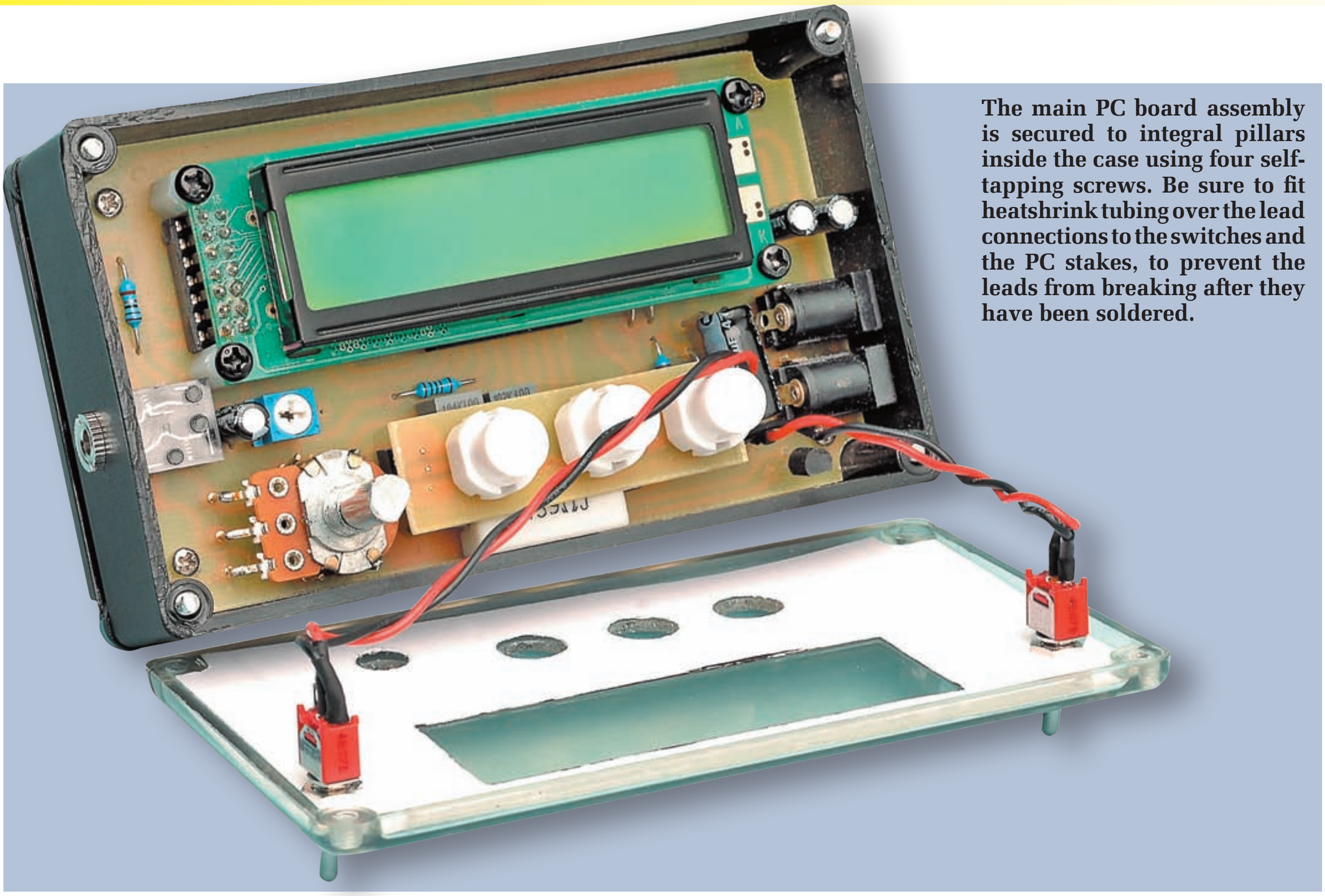
Once these checks have been completed, install the two wire links then solder the resistors in position. Table 1 shows the resistor colour codes, but you should also check each value



The main PC board assembly is completed by plugging the switch board into its matching header strips.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	2	220Ω	red red brown brown	red red black black brown
❑	2	150Ω	brown green brown brown	brown green black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown
❑	1	2.2Ω	red red gold brown	red red black silver brown



The main PC board assembly is secured to integral pillars inside the case using four self-tapping screws. Be sure to fit heatshrink tubing over the lead connections to the switches and the PC stakes, to prevent the leads from breaking after they have been soldered.

using a digital multimeter (DMM) before soldering it to the board.

Follow these parts with the 10 PC stakes. Seven PC stakes are used for potentiometer VR1, three for its terminals and four more to support its body. The remaining three PC stakes are used to terminate the wiring from switches S4 and S5.

Next, install diode D1, Zener diode ZD1 and a socket for IC1, taking care with their orientation. (Do not install IC1 in its socket at this stage). That done, install the 3-way and 4-way single in-line (SIL) socket strips that are used to mount the switch board. These socket strips are made by cutting down an 8-pin IC socket using a hobby knife. Clean up the edges of these socket strips with a small file before soldering them in position.

Similarly, the LCD module is connected via a 14-pin DIL socket strip. This is made by cutting a 14-pin IC socket to produce two 7-way strips, which can then be installed adjacent to each other on the board.

The capacitors can go in next. Note that the electrolytic types are polarised and must be oriented as shown. Note also that the 470μF capacitor goes under the LCD module and must be mounted horizontally (ie, with its body flat against the PC board). The 100μF capacitor to the left of IC1 must also lie horizontally – see photos.

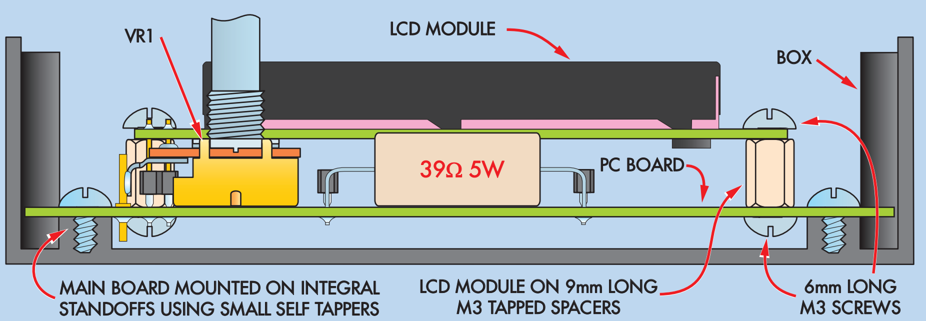


Fig.9: this diagram shows how the main board assembly is secured to the case pillars and how the LCD module is secured to the M3 × 9mm nylon spacers.

Next on the list is regulator REG1. As shown, this device also mounts horizontally on the PC board, with its leads bent down by 90° to go through the relevant holes.

To do this, first bend the two outer leads down about 9mm away from its body and the middle lead down about 6mm away. The device is then fastened into position using an M3 × 6mm screw, nut and washer, and its leads soldered.

Do not solder REG1's leads before bolting its tab down; you could crack the PC tracks or lift the solder pads as the nut is tightened down if you do.

The DC sockets, the 3.5mm PC-mount jack socket and trimpot VR2 can now be installed, followed by potentiometer VR1. Before mounting VR1 though, it will be necessary to cut its shaft to a length of about 14mm (from the end of its threaded boss), to suit the knob used.

As shown in the photos, the pot is mounted upright on the PC board, with its body soldered to four PC stakes. Note that you will have to scrape away some of the coating on the pot body at each solder point, in order to get the solder to 'take'. Once it's in position, solder its three terminals to their adjacent PC stakes.

Parts List – LED Strobe and Tachometer

Main Unit
1 PC board, code 775 (Main), size 115mm × 65mm
1 PC board, code 776 (Switch), size 52mm × 15mm
1 bulkhead case with clear front, 120mm × 70mm × 30mm (Jaycar HB-6082 or equivalent)
1 12V DC 350mA plugpack
1 1W Luxeon white LED or Cree XR-C white LED with collimator lens
1 small torch to house LED and optics
1 2.5mm DC line plug
1 2-line 16-character LCD module, with backlight (Jaycar QP-5516 or equivalent)
1 16mm 10kΩ linear potentiometer (VR1)
1 10kΩ horizontal trimpot (VR2)
1 knob to suit potentiometer
1 20MHz parallel resonant crystal (X1)
2 PC-mount 2.5mm DC sockets
1 PC-mount stereo 3.5mm jack socket
3 click-action PC-mount switches (S1 to S3)
2 sub-miniature SPDT toggle switches (S4,S5)
1 14-pin DIL header (2.54mm pin spacing)
1 4-way SIL header (2.54mm pin spacing)
1 3-way SIL header (2.54mm pin spacing)
1 14-pin DIL IC socket (cut to suit the 14-pin DIL header)
1 8-pin DIL IC socket (cut to make a 4-way SIL socket and a 3-way SIL socket)
1 18-pin DIL IC socket
4 9mm M3 tapped nylon spacers
8 M3 × 6mm screws
1 M3 × 10mm screw
1 M3 nut
4 No.4 × 6mm self-tapping screws
1 80mm length of 0.7mm tinned copper wire
1 500mm length of medium-duty hookup wire
1 30mm length of 1.5mm heatshrink tubing
10 PC stakes

Semiconductors
1 PIC16F88-I/P preprogrammed microcontroller (IC1)
1 7805 5V voltage regulator (REG1)
1 BC337 *NPN* transistor (Q1)
1 1N4004 1A diode (D1)
1 16V 1W Zener diode (ZD1)

Capacitors
1 470µF 16V low-ESR electrolytic
3 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
2 100nF MKT polyester
1 1nF MKT polyester
2 27pF ceramic

Resistors (0.25W, 1%)

1 10kΩ	1 39Ω 5W
2 1kΩ	1 10Ω
2 220Ω	1 2.2Ω

Photo-Interrupter Detector
1 PC board, code 777(Inter.), size 50mm × 25mm (Next month)
1 photo-interruptor (Jaycar ZD-1901 or equivalent)
1 150Ω 0.25W resistor
1 3.5mm stereo jack plug
2 M3 x 6mm screws
2 M3 nuts
3 PC stakes
1 1m length of 2-core shielded cable

IR Reflector Amplifier
1 PC board, code 778 (IR Reflect Amp), size 53mm × 32mm (Next month)
1 plastic utility box, 82mm × 53mm × 31mm
4 M3 tapped 6mm nylon spacers
4 M3 × 12mm countersunk screws
4 M3 nuts
1 LM358 dual op amp (IC2)
1 infrared photodiode (IR SENS1)
1 infrared LED (IR LED1)
2 100µF 16V PC electrolytic capacitors
1 10µF 16V PC electrolytic capacitor
1 1m length of twin-core shielded cable
1 cable gland to suit 3mm cable
1 3.5mm stereo PC-mount jack socket
3 PC stakes

Resistors (0.25W, 1%)

1 470kΩ	2 1kΩ
2 100kΩ	2 150Ω
1 10kΩ	

All printed circuit boards will be available from the *EPE PCB Service*

The LCD module is connected via a 14-way pin header strip at one end and is supported on four M3 × 9mm nylon spacers at its corner positions. We'll describe how the header strip is fitted to the LCD module shortly. For the time being, just fit the four nylon spacers to the PC board and secure them using M3 × 6mm machine screws.

Switch board

There are just three switches and two header strips on the switch board – see Fig.8. Install the three switches first, taking care to ensure that the flat side of each switch is oriented correctly. The 3-pin and 4-pin header strips can then be installed.

Both headers are mounted on the copper side of the board. In each case, the longer pins of the header are first pushed into their mounting holes so that they sit about 1mm above the top of the board. That done, solder the pins to the board pads, then slide the plastic spacer along the pins towards the PC board, so that it rests against the soldered joints – see photo.

Once the assembly is finished, the assembled switch board can be plugged into the main board.

Fitting the LCD header

The next step in the assembly is to fit a 14-pin DIL header to the left-hand end of the LCD module. As before, this header is installed from the underside of the module.

Before soldering the header pins, you first have to adjust the plastic

Specifications

RPM range: 1 RPM (0.0166Hz) to 65,535 RPM (1029Hz) recommended maximum

Accuracy: within 1 RPM at 17,000 RPM, 1.33 RPM at 20,000 RPM

Adjustment: 100 RPM coarse steps with seperate 1 RPM fine adjustment over 100 RPM range

Display: both RPM and Hz

Display resolution: 1 RPM and 0.01Hz

Flash period: adjustable from 32μs to 6.50ms in 25.4μs steps, or adjustable from 1-10% of period

Display update period: 200ms but can be slower for measurements below 300 RPM (5Hz) and with averaging.

Division ratios: 0.5, 1, 2, 3, 4, 5, 6, 7 and 8

Flash position: can be shifted to any pulse edge or edge number when the division ratio is 2 or more

Averaging: from 1-10 measurements for measurements over 300 RPM, reducing in number at lower RPM

Trigger edge: rising or falling (user selectable)

Flash period: setting can be either fixed or automatic

Flash delay from triggered edge to flash: 8.75μs

Reflective trigger range: 65mm for off-white plastic, 95mm for white paper

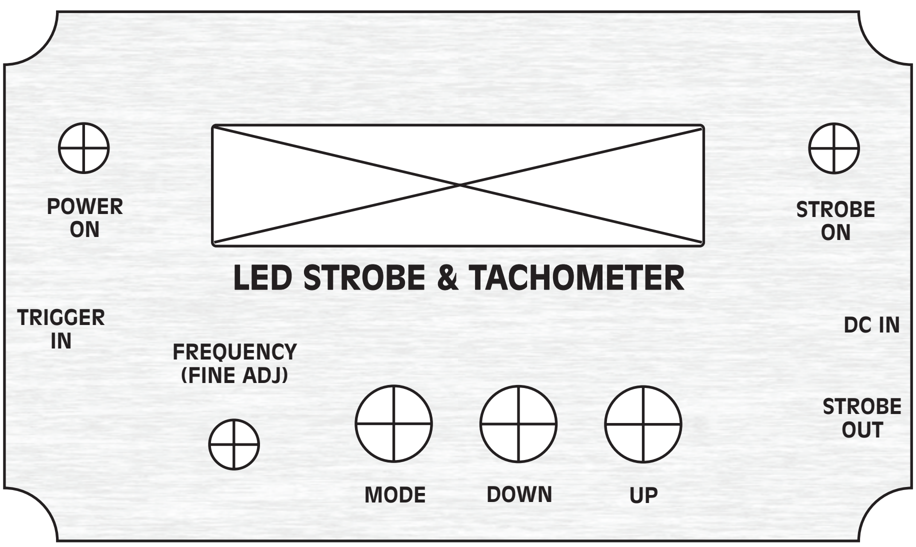


Fig.10: this full-size artwork can be used as a drilling template for the front panel.

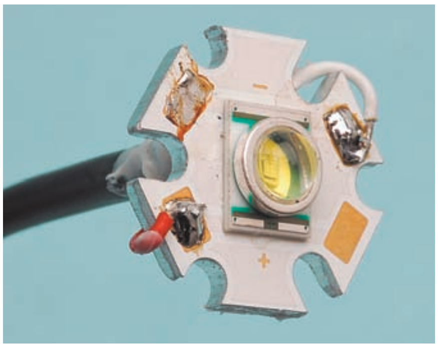
spacer so that the pins will protrude exactly 8mm below the module's PC board. This is done by simply placing the pins on a flat surface and then sliding the spacer along them in one direction or the other so that the pin length below the spacer is about 5.5mm (the spacer thickness is 2.5mm).

Once this adjustment has been made, the header can be installed from the underside and the pins soldered to the pads on the top of the module. Don't plug the LCD module in at this stage though.

Voltage checks

Before applying power, check that IC1 is out of its socket and that the LCD module is also unplugged. That done, temporarily wire in power switch S4, apply power and check for 5V between pins 14 and 5 of IC1's socket. If this is correct, switch off, remove the switch and install both IC1 and the LCD module.

Note that there is a tab beneath the LCD module (bottom, centre) that needs to be bent flat against the module's PC board, so that it clears IC1.



A larger-than-life size view of the 1W white LED. It is wired using a 1.5m length of shielded 2-core cable. Solder the red wire to the positive terminal and the white wire to the negative terminal and cut the shield wire off short.

Secure the LCD module in place using four M3 × 6mm screws.

Preparing the case

If you are buying a complete kit, the case will probably be supplied pre-drilled and with screen-printed lettering. If not, then you will have to drill the holes yourself.

The first step is to drill two 6mm holes in the side of the case to provide access to DC sockets CON2 and CON3. These holes should be located 9mm down from the top of the base and 17mm and 27mm in from the outside front edge.

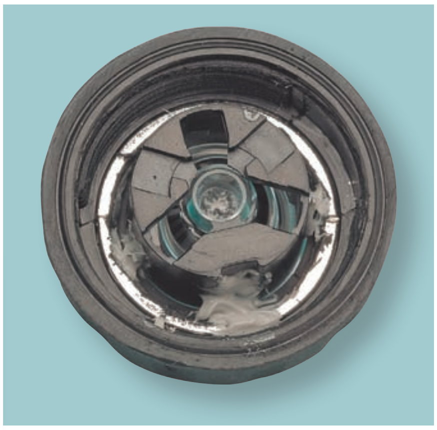
Next, drill another 6mm hole in the other end of the case for CON1. This hole must be positioned 13mm down from the top and 29mm in from the outside top-front edge of the case. The PC board can then be fitted in place and secured on the integral standoffs using No.4 self-tapping screws.

Now for the lid, Fig.10 shows the full-size artwork for the lid, and this can be photocopied and attached to the inside of the lid and used as a drilling template. You can also photocopy the magazine artwork for the case front panel.

All holes in the lid should initially be drilled using a small pilot drill, then carefully enlarged to size using a tapered reamer. Switches S1 to S3 require 10mm holes, S4 and S5 require 5mm holes and VR1's shaft requires a 7mm hole.

Once the holes have been drilled, fit switches S4 and S5 and wire them to the PC board. It's a good idea to fit heatshrink tubing over these connections, to prevent the wires from breaking (hint: push the heatshrink

The connecting cable is secured to the back of the 1W white LED assembly using silicone sealant.



Silicone sealant is also used to secure the collimator lens inside the front assembly of the torch.

The 1W white LED is then clipped into the collimator lens and secured using additional silicone sealant.

tubing over the switch wires before soldering the connections, then slide the tubing into place and shrink it down).

Testing

The first step here is to apply power and adjust VR2 for best contrast on the LCD. The display should show a reading of between 1000 RPM and 1100 RPM on the top line and 16.66Hz on the bottom line. The Mode should be GEN.

If this checks out, attach the lid and mounting brackets to the case using the four screws supplied.

Now check that the RPM value can be adjusted over a 100 RPM range using potentiometer VR1. Similarly, the UP and DOWN switches should change the reading in 100 RPM steps.

The default flash period is set to automatic at 5% in generator mode. In the triggered mode, the defaults are: edge is rising, division is 1, flash period is automatic at 5% and averaging takes place over two measurements.

The assembly of the main unit is now complete. Now let's build the strobe unit.

Strobe construction

As shown in the photo above, the 1W white LED for the strobe is housed in a small plastic torch housing. The original reflector inside the torch was removed and the LED and its associated collimator lens placed just behind the front torch lens.

Depending on the torch, the reflector may be easy to remove or it may be integrated with the screw thread that secures the front assembly to the torch body. In the latter case, the reflector can be removed by cutting around its perimeter using a hobby knife.

This is the completed strobe assembly. A knot tied in the cable (or a cable tie) will prevent the cable from being pulled out through the end cap.

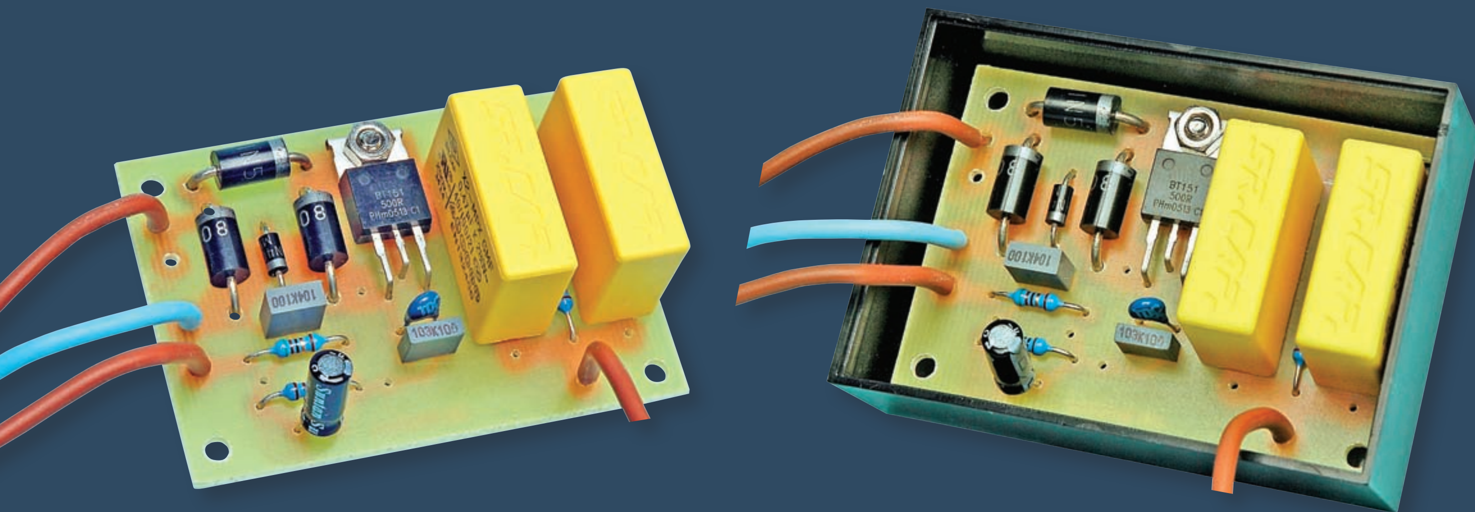
The 1W white LED is wired using a 1.5m-length of shielded 2-core cable. Connect the red wire to the positive LED terminal, the white wire to the negative terminal and cut the shield wire off short. Once it's wired, secure this lead to the back of the LED assembly using silicone sealant.

Silicone sealant is also used to secure the collimator lens to the front lens assembly of the torch. Once it's in place, leave it to cure for several hours, then clip the LED assembly to the back of the collimator lens and secure it using additional silicone sealant. Leave this assembly to cure overnight.

Once the silicone has cured, feed the lead from the LED through a hole drilled in the rear end-cap of the torch. Use a cable tie or tie a knot in the wire to prevent the wire being pulled out of the end of the torch when the end-cap is refitted.

The far end of the cable is fitted with a 2.5mm DC plug. Connect the red (positive) lead to the centre pin of the plug and the white (negative) lead to the earth terminal.

That's all we have space for this month. Next month, we'll show you how to build the IR Reflector Amplifier and Photo-Interrupter boards and describe how the unit is used. ***EPE***



Replacement CDI Module for small petrol motors

By JOHN CLARKE

If the CDI module in your motorbike, outboard, ride-on mower or other small petrol motor fails, you could be in for a shock. Depending on the brand or model, they can cost up to £200. You can build this one for less than £30 – and it will do the same job for most engines.

READERS have been asking us for years to design a drop-in CDI module for motorbikes, outboards and other small petrol motors. You can understand why. It can be a real shock to visit your local dealer and find out the price for such a module. It is even harder to justify the prices charged when you see the circuit components involved in these units.

These days, a great many small petrol engines use a 'capacitor discharge ignition' (CDI) module. The high-voltage capacitor is charged directly from a generator located on the flywheel. A battery may still be included and used to drive lights and ancillaries, but this is used independently of the ignition.

Great improvement

CDI is a great improvement on the old magneto ignition systems. Not only does the CDI deliver higher spark energy, but it also dispenses with the points, which were inevitably subject to wear and required periodic cleaning, adjustment and replacement.

The one drawback is that CDI systems don't last forever – they can fail. While the failure can be within the flywheel generating coils or the ignition coil, it is most likely to be the CDI module itself – and then you will find that the replacement can be very expensive.

The CDI Module described here may be used to replace a failed factory unit for an engine that incorporates a generator and trigger coil to provide the high-voltage and the firing point. Most of these CDI systems operate in a similar way, but there are variations in design that use the opposite polarity for voltage generation and are therefore unsuitable for our module.

While some tests can be performed to check for suitability, we cannot guarantee that the module will work for

every engine. Even so, because this CDI Module uses cheap and readily available parts, it may be worth a try if you are unwilling to fork out lots of hard cash for a genuine replacement module.

How CDI works

The connections required for a typical CDI module are shown in Fig.1. The generator (magneto) coil provides the high voltage to charge a capacitor (in the CDI module), while the trigger coil provides the signal to dump the capacitor's high voltage charge into the ignition coil. A kill switch shunts the high-voltage supply from the generator to prevent ignition.

Fig.2 shows how CDI works. It comprises three main components: the ignition coil, a capacitor (C1) and a silicon-controlled rectifier (SCR). The SCR behaves as a switch. It is normally a high impedance until a small trigger voltage is applied between its gate (G) and cathode (K). It then conducts and behaves like a diode. After triggering, the SCR switches off when the current through it falls close to zero.

Initially, the SCR is off and capacitor C1 is discharged. A positive voltage from the generator then charges C1 via diode D1 and the primary winding of the ignition coil. The current path is shown in red as 'I_C'.

Capacitor C1 is discharged when the SCR is subsequently triggered, allowing current to flow back through the ignition coil primary. This current path is shown in green as 'I_D'. The fast discharge of C1 and resulting current through the ignition coil causes a high voltage to be developed across the secondary winding of the ignition coil, to fire the spark plug(s).

Once the spark plug is extinguished, the collapsing field of the ignition coil develops a reverse current flow via diode D2 to partially recharge capacitor C1.

Typically, the generator coil delivers about 1A in charging the capacitor up to about 350V. If C1 is 1μF, then it will charge in about 350μs – much quicker than the time between sparks, even in a high-revving engine.

No RPM advance

Note that the CDI Module does not incorporate RPM advance and so it provides a fixed timing from the trigger coil – which is common with small engines.

Some engines do incorporate RPM advance using a special trigger coil and magnetic core design that advances the firing edge with increasing RPM. This is achieved by having a stepped or shaped coil core that has a larger gap at its leading edge compared to the trailing edge – see Fig.3.

At low speeds, the coil voltage required for triggering is developed at the trailing edge of the magnet, but as the revs increase, the leading edge of the magnet is able to induce more voltage in the coil and so firing occurs earlier. This is shown in Fig.4.

Other designs use electronic advance, but these require extra power for the circuit and tend to be used only with battery-powered systems.

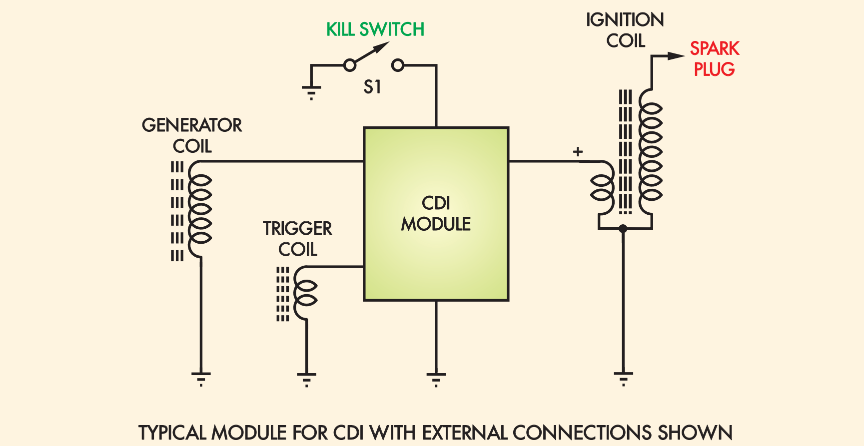


Fig.1: this shows how a typical CDI module is connected. The generator (magneto) coil provides a high voltage to charge a capacitor in the CDI module, while the trigger coil provides the timing signal to dump the capacitor's high voltage charge into the ignition coil.

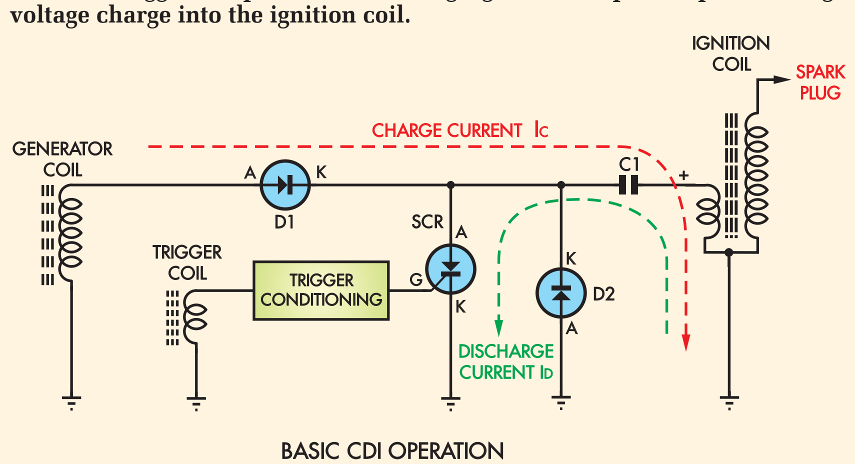


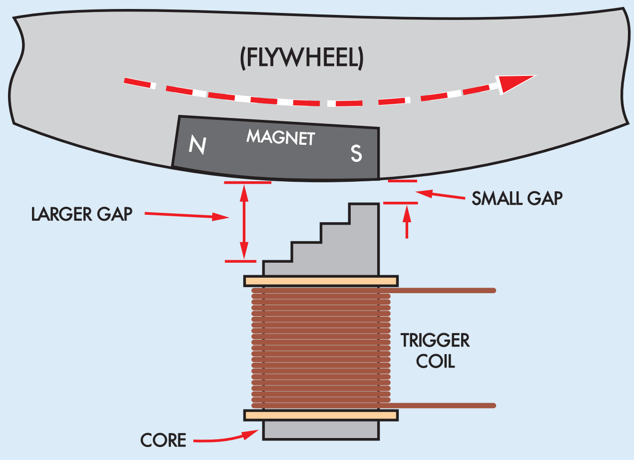
Fig.2: how the CDI module works. Initially, the generator coil charges C1 to a high voltage (via diode D1). A trigger pulse (from the trigger coil) then turns on the SCR and this quickly discharges C1 by allowing current to flow back through the coil primary.

Circuit details

The simplest circuit arrangement for the CDI Module is shown in Fig.5. An extra features version is shown in Fig.6. Voltage from the generator coil charges capacitor C1 (and C2) via diode D1 and the ignition coil primary. As previously mentioned, diode D2 is there to conduct the reverse current flow from the ignition coil after the capacitor has discharged.

The two in-series 1MΩ resistors across capacitor C1 are there to discharge the capacitor if the SCR does not fire. This is a safety feature that prevents a nasty electric shock if you happen to connect yourself across the capacitor. It takes about two seconds for the capacitor to discharge to a safe value.

Provision has been made on the PC board for two discharge capacitors, C1 and C2. This allows the use of either two 0.47μF capacitors or two 1μF capacitors. A higher capacitance will produce greater spark energy, provided the generator coil can charge



ADVANCE TRIGGER HEAD DESIGN

Fig.3: some engines achieve RPM advance using a special trigger coil with a stepped magnetic core that has a larger gap at its leading edge compared to the trailing edge. This advances the firing edge with increasing RPM.

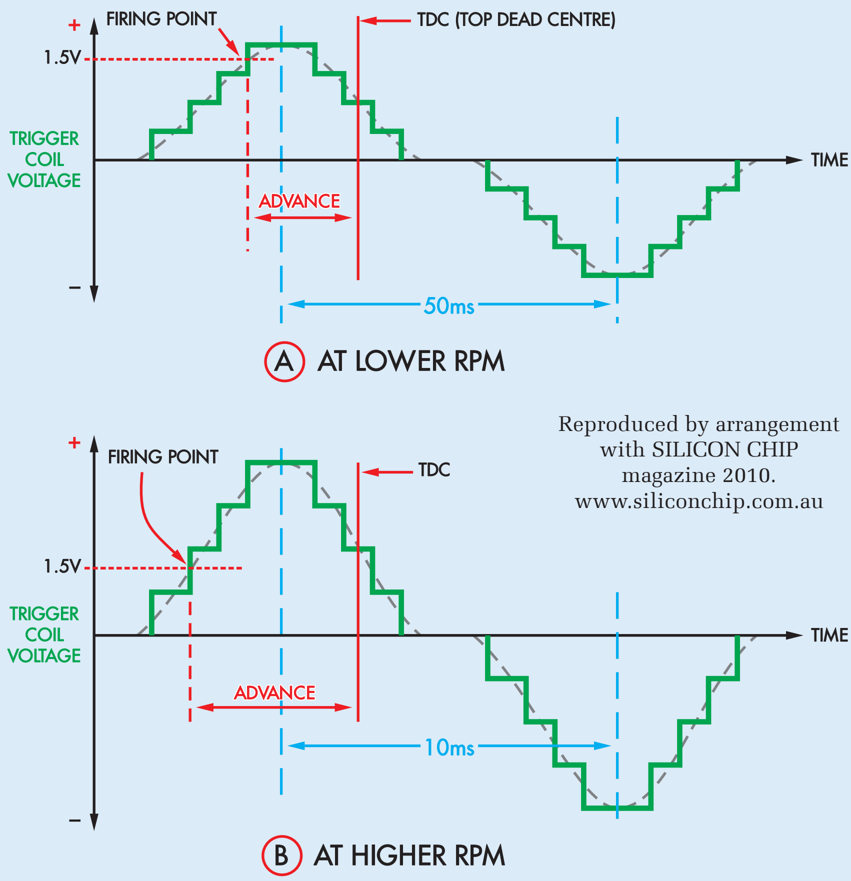


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Fig.4: the effect of a stepped trigger core design is shown in these timing advance waveforms. At low speeds, the coil voltage required for triggering is developed only at the trailing edge of the magnet (waveform A). However, at higher revs, the leading edge of the magnet induces a greater voltage into the coil and so firing occurs earlier (waveform B).

the capacitors to the full voltage in the required time.

The trigger coil provides the necessary signal to trigger the SCR. When the coil voltage goes positive, it feeds current to the gate of the SCR via a 51Ω resistor and diode D3. D3 prevents reverse voltage on the gate, while the 51Ω resistor limits the gate current to a safe value. A 1kΩ resistor ties the gate to ground to prevent false triggering, while the 100nF capacitor filters noise and transients that may cause the SCR to trigger at the wrong time.

A kill switch connection has also been provided to shunt the generator current to ground and stop the motor.

Circuit refinements

The simple circuit of Fig.5 works well, but additional circuitry can improve reliability and provide for more consistent triggering. The extended circuit is shown in Fig.6.

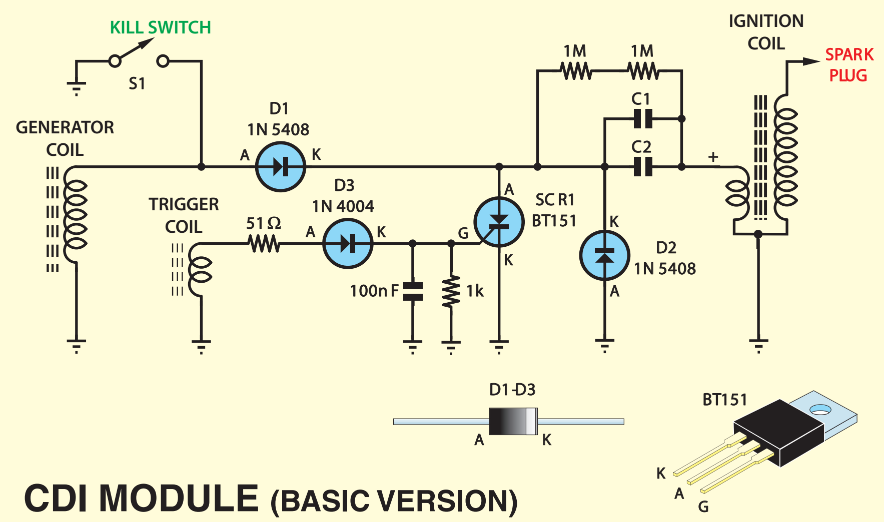
First, diode D4 has been added across the generator and this shunts negative excursions across the coil to less than –0.7V. Without D4, the anode of diode D1 can be subject to –350V from the negative swings of the generator. This means that diode D1 could have over 700V across it if the capacitor is charged to +350V.

While D1 is rated at 1000V, D4 reduces the maximum likely voltage across it to around 350V or so, and thereby reduces the possibility of reverse breakdown of the diode.

Triggering in this version of the circuit has also been improved in two ways. First, we have added a series 10µF capacitor to the gate of the SCR. This capacitor prevents false triggering due to any DC offset from the trigger coil that may be more positive than it should be because of remnant magnetism in the coil's core. The 1kΩ resistor across the capacitor is there to discharge the capacitor; it is high enough in value to prevent it triggering the SCR on its own. Diode D5 prevents the 10µF capacitor from being charged with reverse polarity when the trigger coil output swings negative.

The second improvement involves the use of a negative temperature coefficient (NTC) thermistor across the gate of the SCR. This thermistor reduces its resistance with increasing temperature and is used to compensate for the lowered triggering requirement of the SCR (for both voltage and current) at higher temperatures.

Effectively, the NTC thermistor forms a voltage divider with the 51Ω resistor. At 25°C, the thermistor is 500Ω, and so it attenuates the signal from the trigger coil to 91%. However, at 100°C, the NTC thermistor resistance is around 35Ω and the trigger signal is divided down to 41% of the



CDI MODULE (BASIC VERSION)

Fig.5: this is the circuit for the Basic Version. The kill switch is there to stop the motor by shunting the generator coil's output to ground, while the 1kΩ resistor on SCR1's gate prevents false triggering due to noise.

trigger coil value.

This attenuation in signal level attempts to match the SCR's reduced trigger level requirement at higher temperature. So as the temperature rises, the signal is increasingly attenuated and as a consequence, the SCR fires at the same trigger coil voltage over a wide temperature range.

Without the thermistor (see Fig.6), the SCR would be subject to timing changes with temperature.

Construction

A small PC board coded 772, measuring 64mm × 45mm, caters for both versions of the circuit. This board is available from the *EPE PCB Service*. The PCB can fit into a plastic utility box that measures 70mm × 50mm × 20mm, which allows the whole module to be subsequently potted.

Begin construction by checking the PC board for the correct hole sizes. The four corner mounting holes should be drilled to 3mm, as should the hole for the SCR mounting tab. That done, check the PC board for breaks in the copper tracks or for shorts between tracks. Make any repairs to the board before assembly commences.

The component layout for the simple version of the circuit is shown in Fig.7, while Fig.8 shows the more

Parts List – CDI Module

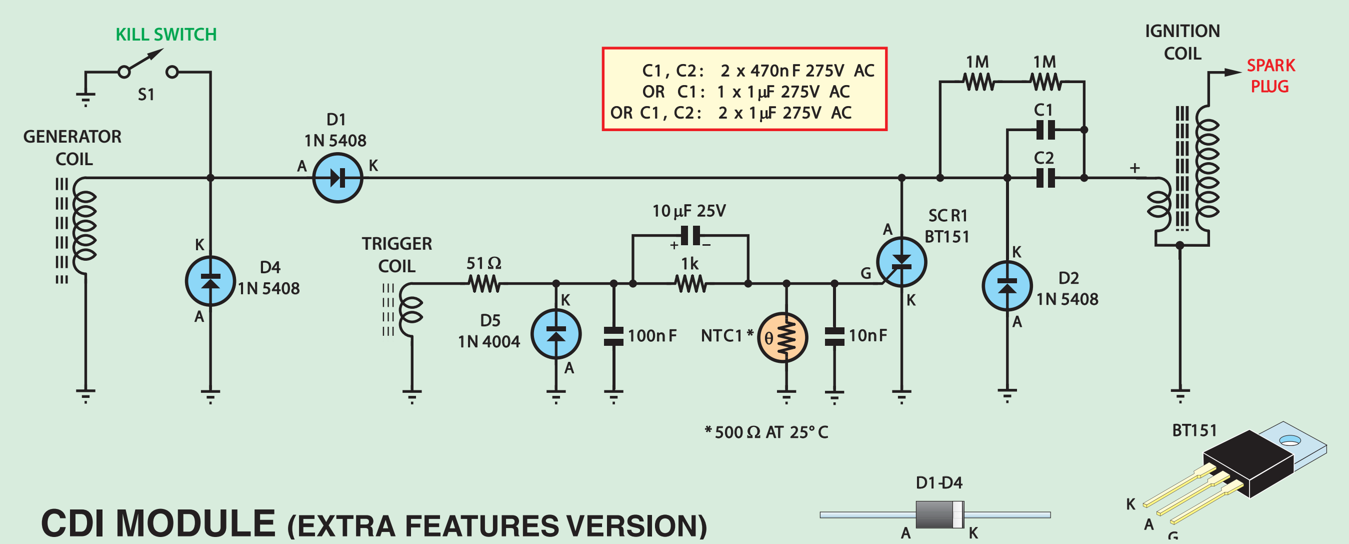
1 PC board, code 772, available from the *EPE PCB Service*, size 64mm × 45mm
1 potting box, 70 × 50 × 20mm
1 500Ω NTC thermistor (500Ω at 25°C)
1 M3 × 10mm screw
1 M3 nut

Semiconductors
1 BT151 500V SCR (SCR1)
3 1N5408 3A 1000V diodes (D1,D2,D4)
1 1N4004 1A 400V diode (D3 for Basic Version; D5 for Extra Features Version)

Capacitors
1 10µF 25V radial electrolytic
1 1µF 275V AC or 280V AC metallised polypropylene; or
2 0.47µF 275V AC or 280V AC metallised polypropylene; or
2 1µF 275V AC or 280V AC polypropylene – see text
1 100nF MKT polyester
1 10nF MKT polyester

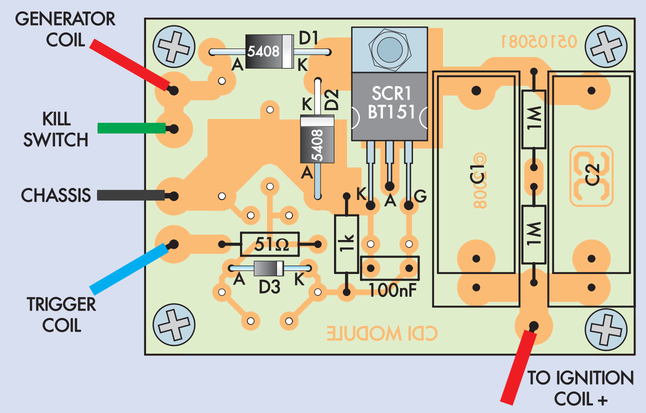
Resistors (0.25W 1%)
2 1MΩ 1 51Ω
1 1kΩ

Miscellaneous
Automotive wire, crimp connectors, neutral-cure silicone sealant.



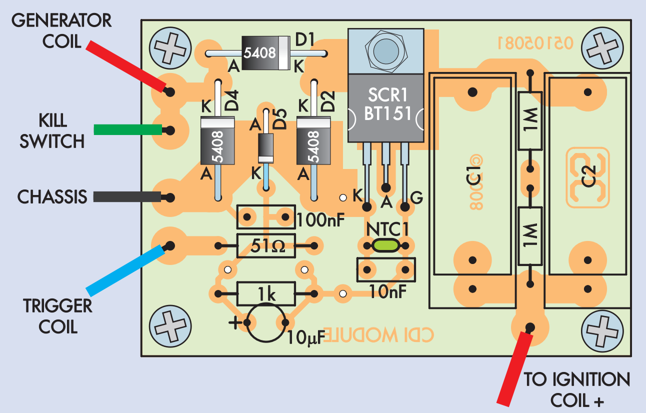
CDI MODULE (EXTRA FEATURES VERSION)

Fig.6: the Extra Features Version includes diode D4 to shunt negative excursions across the generator coil to less than –0.7V, and thus limit the voltage across diode D1 to around 350V. It also features an improved trigger circuit, to ensure consistent firing of the SCR with variations in temperature.



'BASIC' CDI VERSION

Fig.7: follow this parts layout diagram to build the 'Basic Version' of the CDI Module. It can be used for non-critical applications.



'EXTRA FEATURES' CDI VERSION

Fig.8: the 'Extra Features' version is the one that we recommend you build. Take care with the orientation of the diodes and the 10µF electrolytic capacitor.

complex version. The choice is yours, but we recommend the version in Fig.8. In fact, the following assembly procedure assumes that you are building the 'extra features' version.

Start by installing the diodes, taking care to orient each one correctly. The resistors can then go in – their values can be checked against the accompanying table and with a digital multimeter.

Next, install the thermistor, the smaller capacitors and the 10µF electrolytic, making sure it is oriented correctly. The discharge capacitor(s) can then be installed. As noted above, we have provided for two capacitors and also for two different lead spacing on the PC board.

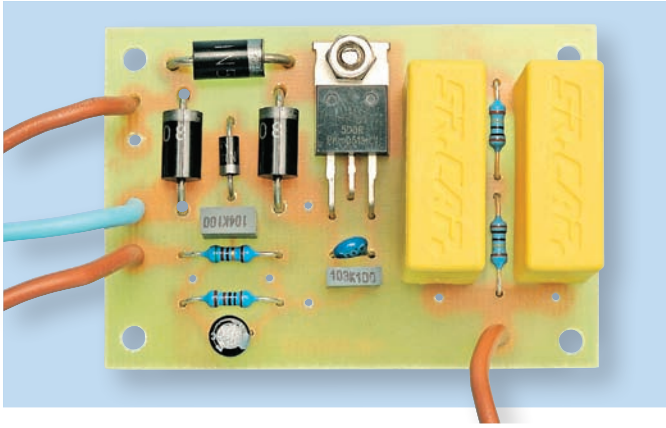
The SCR is mounted horizontally with its leads bent down by 90° so that they pass through their holes in the PC board. Secure its tab using an M3 × 10mm screw and M3 nut *before* soldering the leads.

Wiring

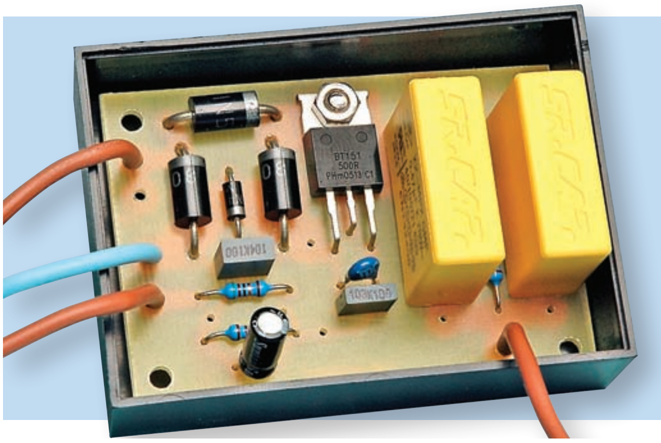
Next, add the wiring from the PC board to the generator coil, kill switch and to the ignition coil. The leads must all be rated at 250V AC and 7.5A. Automotive wire should be suitable, or you can use 230V AC mains wire salvaged from a mains extension cord. The wiring for the chassis connection should also be rated at 7.5A or more.

By contrast, the trigger lead does not have to be heavy duty, but should have suitable insulation for automotive use. Sheath the wires in some flexible tubing to prevent possible chaffing of the wiring insulation. Better still, you may be able to use the existing wiring for the original CDI module.

If you want the best spark possible, you can try adding a second 1µF capacitor in parallel with the first. This



This completed CDI module is the 'Extra Features' version. You may have to experiment with the number of discharge capacitors to get the best spark – see text.



The board should be installed in a plastic case and potted using *neutral-cure* silicone sealant to ensure reliability (ie, to protect against vibration, moisture and dust).

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	1MΩ	brown black green brown	brown black black yellow brown
❏	1	1kΩ	brown black red brown	brown black black brown brown
❏	1	51Ω	green brown black brown	green brown black gold brown

Warning

This CDI Module is not intended for use as a replacement for CDI units that generate their own high voltage from an inverter requiring a 12V battery supply.

To replace one of these units, you could adapt one of our previous designs, such as the Programmable Ignition System that appeared in *EPE* from September, October, November 2009.

may improve the 'fatness' (intensity) of the spark. In some cases though, a 1μF capacitance will give the best spark because 2μF may load the generator coil too much and lower the charge voltage.

Once the board is complete, run the external connections and test the CDI for correct operation. Adjust the ignition timing according to the manufacturer's instructions.

Potting the circuit

As previously indicated, we used a potting box (Jaycar Cat. HB-5204) to house the CDI unit. Potting allows the components to be protected from vibration, water and dust. You must use a 'neutral-cure' silicone sealant for this job.

Do not use an 'acid-cure' silicone, as this will corrode the wires and copper pattern on the PC board.

Note that the capacitor(s) will protrude a little from the top of the potting box. The box can be mounted on the engine frame using suitable brackets. It should be placed away from the exhaust side of the engine.

Make sure that any mounting screws for the box do not penetrate and make contact with the circuit.

Testing the generator coil

Sometimes the generator coil can fail due to either a shorted turn or a broken wire. You can test for a break in the coil by measuring its resistance – ie, between its output and ground. If the coil is OK, its resistance will probably be less than 200Ω.

A shorted turn is not easily checked except using a special shorted turns tester. However, you can get some idea if the coil is delivering sufficient voltage by measuring it with a multimeter set to read AC volts up to 300V. The voltage is measured when the engine is turned over.

Take care if making this measurement, since the generated voltage can give you an electric shock. DO NOT touch any of the wiring when turning the motor over.

Note that the voltage measured across the generator coil will not be anywhere near the voltage that it develops when running. That's because the multimeter does not respond well to the low-frequency voltage fluctuations that occur when kicking the engine over. In addition, most multimeters do not respond to the peak of the waveform but to the average of a sinewave.

In practice, you should get a reading of about 50V AC from the coil.

Another way of testing the coil voltage is to connect the CDI module and measure the DC voltage between the cathode of diode D1 and the chassis while kicking the motor over. The reading should at least get to 200V DC if you can kick the motor over fast enough.

Alternatively, if an oscilloscope is available, the voltage waveform can be measured with the probe set to 10:1.

One point we have not mentioned is the polarity of the voltage. The capacitor needs to charge to a positive voltage before the trigger signal occurs. **If the voltage from the generator coil is negative before triggering occurs, it will mean that the CDI module described here is not suitable for replacing the module in your engine.**

You can check the polarity using a multimeter set to DC volts – it's just a matter of checking the voltage on SCR1's anode (A) goes positive before the SCR is triggered and negative after the trigger.

Trigger coil testing

The trigger coil can be tested in the same way as the generator coil (ie, measure the voltage between diodes D3 or D5's cathode and chassis as the motor is kicked over). This voltage will be quite small compared to that from the generator coil, and only occurs over a short portion of each engine revolution.

Typically, you might measure a trigger voltage of less than 1V using a multimeter set to read AC volts. The trigger coil voltage can also be observed on an oscilloscope.

Of course, the real test is when it is used with the CDI module itself, as it must be able to trigger the SCR. *EPE*

Bridge adaptor for stereo power amplifiers

Four times the power of a single module

Would you like to connect a stereo amplifier in 'bridge mode' in order to deliver double the power to a single loudspeaker system? This simple adaptor allows you to do it, without any modifications being necessary to the power amplifiers themselves.

By LEO SIMPSON

WE regularly get requests from readers asking how to connect a stereo power amplifier in 'bridge mode', but up until now we have not had a specific project article to suit the application. Then we received an email from a reader asking how to run the SC480 amplifier modules in bridge mode, just as we were proof-reading an article on the *Balanced/Unbalanced Converter for Audio Work* (see September 2010 *EPE*. We immediately realised that half of that project would provide the needed adaptor.

Before going into the details, let's briefly describe how a pair of power amplifiers can be run in bridge mode to extract more power. Fig.1 shows the set-up. For a start, you must have two identical power amplifiers, and this is why this arrangement is often convenient with a stereo amplifier.

Out-of-phase signals

The two power amplifiers are driven with signals that are out-of-phase by 180°. If we consider a sinewave signal (or any other audio signal for that matter), when one power amplifier is delivering the positive half cycle of the waveform, the other amplifier will be delivering the negative half-cycle. The amplifiers drive a single loudspeaker, and the result is that the two amplifier voltage waveforms are added – ie, we

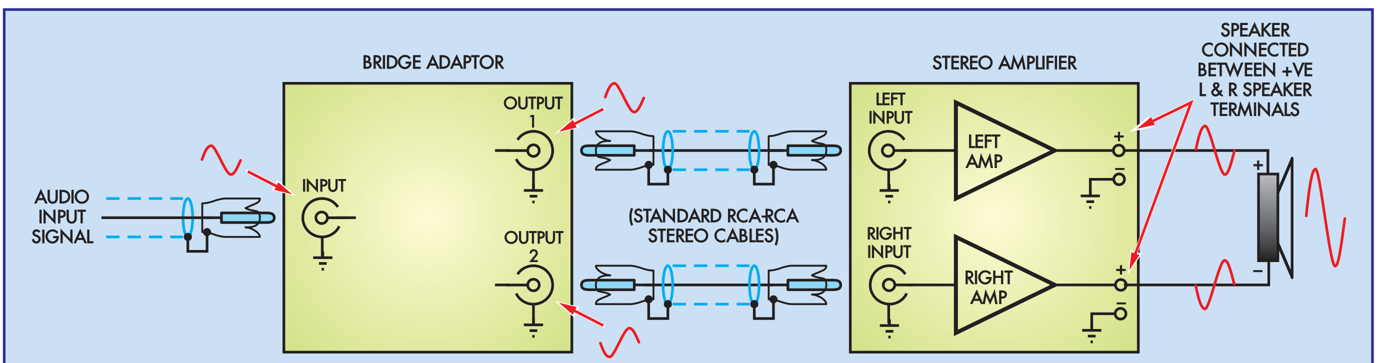
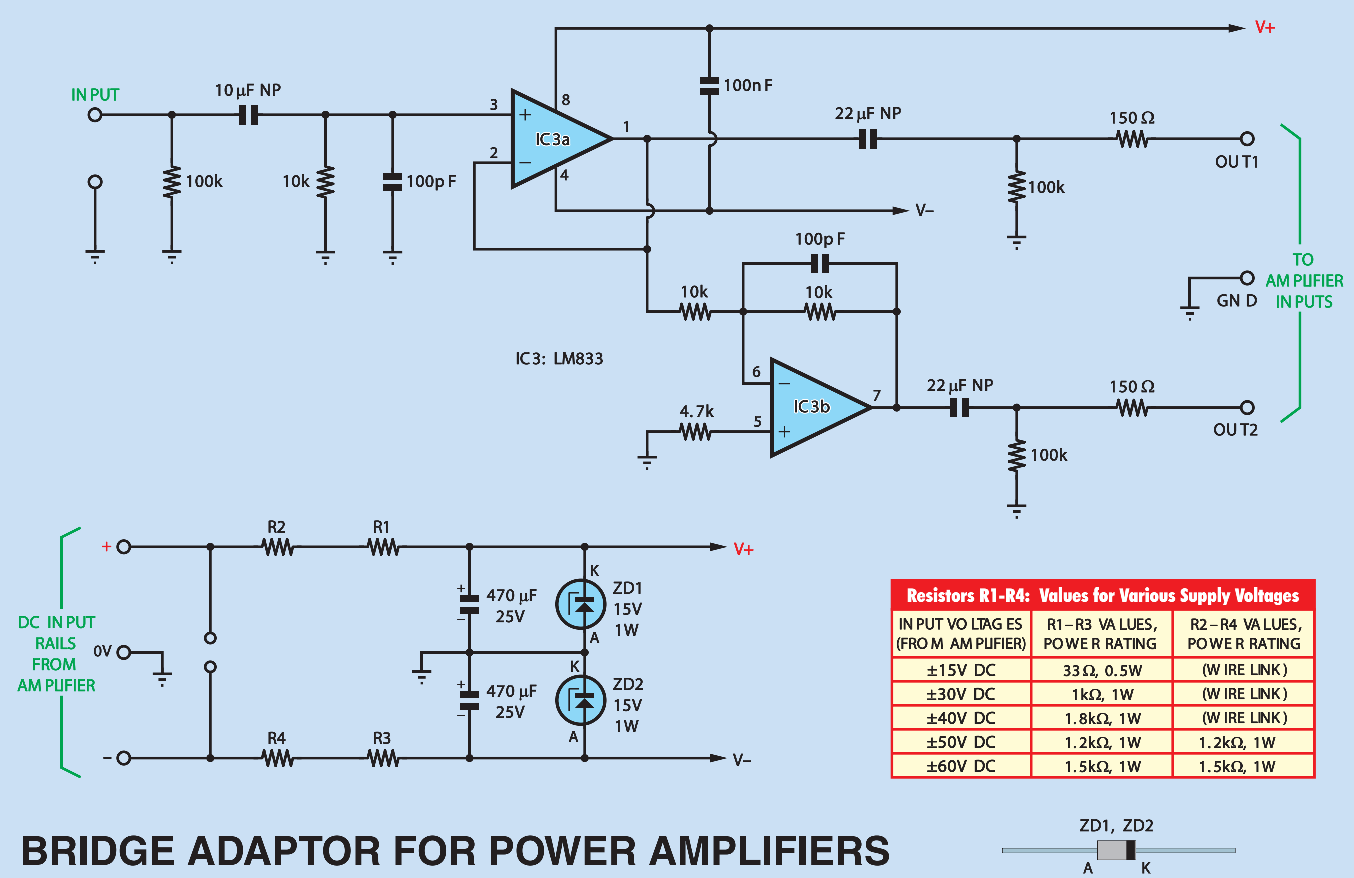


Fig.1: this diagram shows how the Bridge Adaptor is connected to two power amplifiers to drive a single loudspeaker. Note that only the active output terminals of the power amplifiers are connected to the loudspeaker, while the ground terminals are not connected.



Resistors R1-R4: Values for Various Supply Voltages		
INPUT VOLTAGES (FROM AMPLIFIER)	R1–R3 VALUES, POWER RATING	R2–R4 VALUES, POWER RATING
±15V DC	33Ω, 0.5W	(WIRE LINK)
±30V DC	1kΩ, 1W	(WIRE LINK)
±40V DC	1.8kΩ, 1W	(WIRE LINK)
±50V DC	1.2kΩ, 1W	1.2kΩ, 1W
±60V DC	1.5kΩ, 1W	1.5kΩ, 1W

BRIDGE ADAPTOR FOR POWER AMPLIFIERS

Fig.2: the Bridge Adaptor uses a dual op amp to provide 'in-phase' and 'out-of-phase' signals to drive two power amplifiers and a single loudspeaker.

get double the output voltage of one amplifier across the loudspeaker.

Since power is 'voltage squared' times current, the resultant power in the loudspeaker is four times the power that could be obtained with one power amplifier driving that same loudspeaker. Well, that's the theory anyway.

In practice, the results may not be quite as good, but it is still a worthwhile exercise if you have two amplifier modules and a single loudspeaker that you want to drive with a lot of power.

What if you use the SC480s?

Let's now consider a real case, as suggested for the SC480 modules in the email mentioned earlier. As originally published and using the specified power supply circuit, the SC480 module is rated to deliver 50W into an 8Ω load and 70W into a 4Ω load. Furthermore, its music power was 77W into an 8Ω load and 105W into a 4Ω load.

Hence, under music power conditions and depending on the regulation of the power supply, two SC480 modules in bridge mode could be expected to deliver over 200W into an 8Ω load. In fact, that is four times the rated power from a single module into an 8Ω load, so our general rule of 'four times the power' is not far off. Note that the continuous power would only be about 150W, or twice the rated power into a 4Ω load.

Do not use a 4Ω speaker

So could we go even further and use a 4Ω loudspeaker instead of an 8Ω model. Well sorry, but that is not possible because it would overload the amplifier modules. The reason for this is that each amplifier in a bridge set-up actually 'sees' half the real load impedance.

So, for the 8Ω example we have just talked about, each SC480 amplifier module sees or behaves as if it was driving a 4Ω load, and it can only deliver the power it would deliver if it was driving a 4Ω load. Why is that?

Consider two modules driving a single 8Ω loudspeaker, with each amplifier delivering a sinewave of 8V. Since the voltages across the speaker are added, the resultant current flowing in it is 16/8 or 2A. So, as far as each amplifier module is concerned, it is delivering 8V, and 2A is flowing – therefore, as far as the amplifier is concerned, it is driving a 4Ω loudspeaker.

Now you know as well as we do that amplifiers are not 'aware' and they cannot think or see, but you get the picture. To repeat the concept: each amplifier in a bridge set-up 'sees' half the real load impedance.

Therefore, if you are going to use a 4Ω load in a bridge set-up, each amplifier must be able to drive a 2Ω load. The SC480 is not rated to drive 2Ω loads and that is the end of the story as far as that module is concerned.

Bridge adaptor circuit

Fig.2 shows the circuit diagram for the Bridge Adaptor For Power Amplifiers. It is, in fact, identical to last month's *Unbalanced to Balanced Output Converter* (September '10). We show it as using one LM833 low-noise dual op amp, which is labelled as IC3.

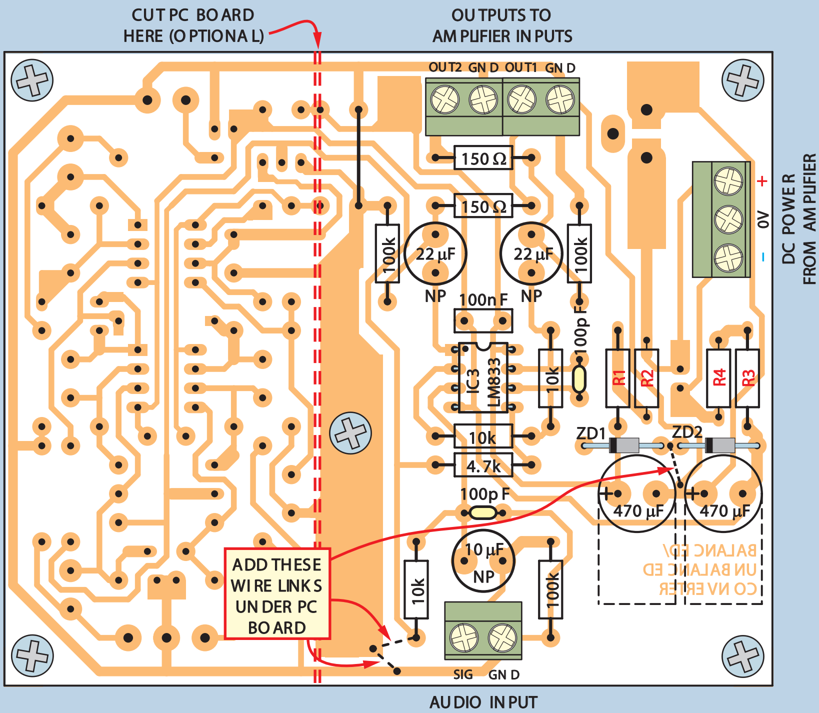


Fig.3: use this diagram to populate the PC board. Only one half of the board is used and the unused section can be cut off if you wish.

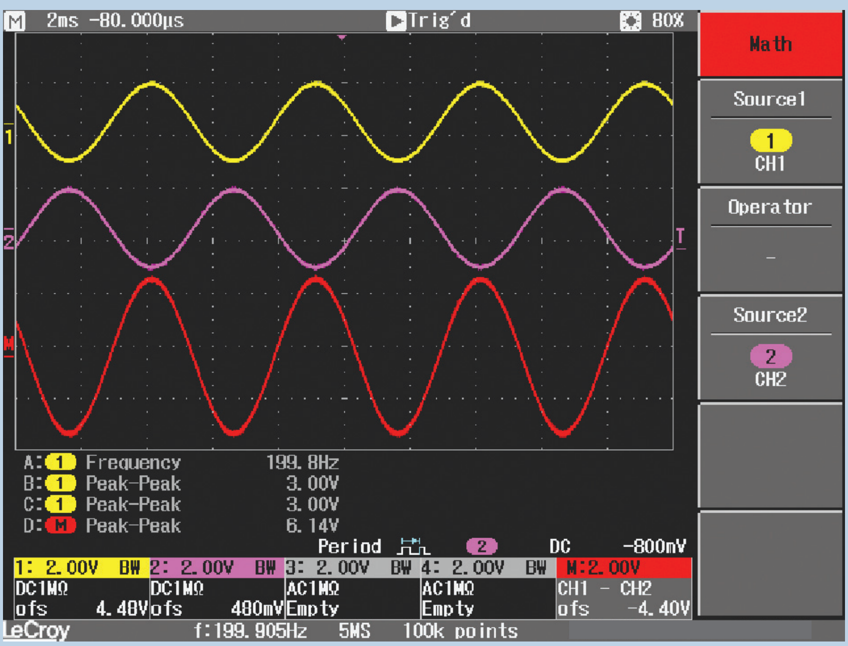


Fig.4: this scope shot shows the principle of bridged power amplifier operation. The two upper traces show the in-phase (yellow) and out-of-phase (purple) signals. The red trace shows the expected signal across the loudspeaker and this is the 'sum' of the two amplifier drive signals which will result in four times the power being delivered into the loudspeaker. In practice, depending on the amplifier output configuration and the power supply regulation, the results may not be quite as good.

Parts List – Bridge Adaptor

1 PC board, code 770, available from the *EPE PCB Service*, size 103mm × 85mm
1 3-way screw terminal blocks (5.08mm or 5mm spacing)
3 2-way screw terminal blocks (5.08mm or 5mm spacing)
3 M3 × 6.3mm tapped stand-offs
3 M3 × 6mm screws
1 60mm length of 0.8mm tinned copper wire (for links)

Semiconductors
1 LM833 dual op amp (IC3)
2 15V 1W Zener diodes (ZD1, ZD2)

Capacitors
2 470µF 25V PC electrolytic
2 22µF NP electrolytic
1 10µF NP electrolytic
1 100nF MKT polyester
2 100pF ceramic

Resistors (0.25W, 1%)
3 100kΩ 1 4.7kΩ
3 10kΩ 2 150Ω
R1-R4: see table in Fig.2

IC1 and IC2 on the same circuit are deleted.

The input signal is fed to op amp IC3a, which is connected as a unity-gain buffer by virtue of the fact that its output (pin 1) is connected directly to its inverting input (pin 2). The output of IC3a is fed via a 22µF non-polarised (NP) capacitor and a 150Ω resistor to become the 'in-phase' output signal to one of the power amplifier modules.

IC3a also drives op amp IC3b, which is connected as an inverting amplifier with a gain of –1, due to the 10kΩ resistors connected to pins 6 and 7. IC3b's output is fed via a 22µF non-polarised (NP) capacitor and a 150Ω resistor to become the 'out-of-phase' output signal feed to the second power amplifier module.

Power supply

The power supply for the Bridge Adaptor assumes that the power amplifier modules will be run from balanced positive and negative supply rails. These supply rails are fed in via series resistors (R1 to R4) and regulated

Still confused as to how it works?

Some readers may still be confused about how feeding out-of-phase signals to a single loudspeaker can result in double the drive voltage (and four times the power). After all, out-of-phase signals cancel, don't they? They may be further confused if they look closely at the scope screen grab (Fig.4) and see that the MATHematical operation used to produce the large amplitude red trace is minus (–).

So let us explain. Normally, if you add two out-of-phase signals using an oscilloscope, they do cancel. The sum would be written as: **V1 + (–V1) = 0.**

However, when you have out-of-phase signals delivered to a loudspeaker (or any other load, for that matter), the loudspeaker always responds to the voltage difference between the two signals. So, if one side of the loudspeaker is at +6V (say) and the other side is at –6V, the total voltage across the speaker will be 12V. Once you have built the Bridge Adaptor and hooked it up to a pair of amplifiers, you can confirm this with a digital multimeter set to a low-voltage AC range.

That is why we set the scope to subtract the signals to portray the correct result. The sum would be written as: **V1 – (–V1) = 2V1**

using two 15V 1W Zener diodes (ZD1 and ZD2) which are each shunted by 470µF 25V capacitors to ensure low hum and noise.

The table (Fig.2) shows the values for various supply combinations. In particular, if you are using the power supply board for the SC480 amplifier modules, they already have provision to provide ±15V supply rails. In that case, you can simply install wire links in place of R2 and R4 and 33Ω resistors for R1 and R3 and omit Zener diodes ZD1 and ZD2. The 33Ω resistors are included to improve the supply filtering (bypassing) in conjunction with the 470µF capacitors.

To illustrate another case, if your amplifier modules use ±50V supply rails, you should install four 1.2kΩ 1W resistors in the R1 to R4 positions.

Construction

As already noted in the above panel, the Bridge Adaptor uses the same PC board as last month's *Balanced/Unbalanced Converter* project. Note, however, only one half of the board is used. This

Circuit Board

For this Bridge Adapator project, you can use the *Balanced/Unbalanced Converter* PC board, code 770. Note, however, that you will still have to install a wire link under the board between the junction of ZD1 and ZD2 and the junction of the two 470µF capacitors. This is necessary because of the different power supply arrangement for the Bridge Adaptor.

You must also install the two wire links to the left of the input terminal block in Fig.3.

board is available from the *EPE PCB Service*, code 770.

The parts layout is shown in Fig.3 and includes three links which must be installed underneath the board. If you want, you can cut off the unused section of the board to make it smaller, but then you should also provide a third plastic stand-off pillar and mounting screw.

Installation is simply a matter of deciding how you want to mount the board in conjunction with your power amplifiers, which may or may not be in a common chassis. We'll leave the details to you. *EPE*

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Recycle It!

BY JULIAN EDGAR

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Personal Computers

An Aladdin's cave of 'goodies'

PERSONAL computers are amongst the most common of electronic goods thrown away. So is it worth picking up discarded ones and pulling them apart for their good internal bits? The answer is usually 'yes' – and two different paths can be taken.

First, if you're really into PCs, you may be able to salvage useful items like sound and video cards, DVD drives, the power supply or even the motherboard. However, the pace of change in PC hardware is so great that in many cases these parts will be outdated or not compatible with other components. But if you know your PC hardware inside out, making use of complete assemblies is the most efficient way of recycling computer parts.

Then there is another way – the approach I'll use here. So what's that then? It's to disassemble the PC down to its component level – obviously, not to every single individual capacitor or resistor, but to the level where you grab just the bits that are useful. So, stand by as I get inside the hard drive, the floppy disc and CD drives, and the power supply! Incidentally, pulling apart the hardware to this level shows how the 'moving parts' of a PC work – ideal for kids who might see the computer as just a 'big box'.

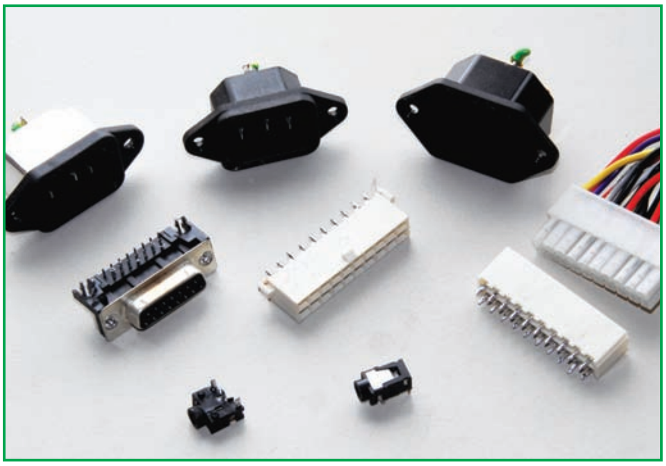
The items shown here were salvaged from two PCs picked up at random at the local rubbish dump.

Plugs and sockets

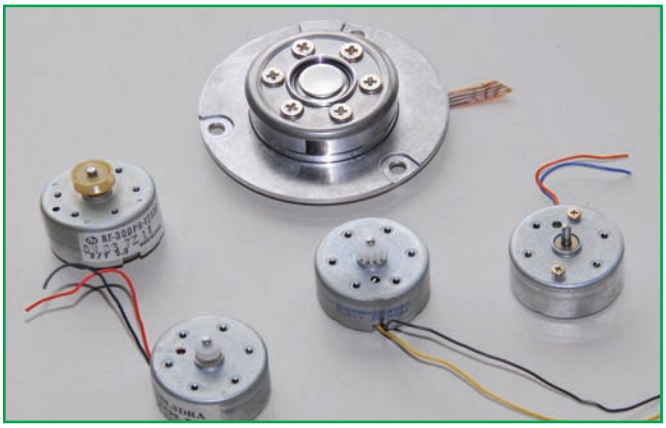
You don't usually think about a PC having lots of salvageable plugs and sockets – until you look inside. There are 1/8th inch stereo sockets (on the sound card), multi-pin DC plugs and sockets (on the power supply, motherboard and the disc drives), IEC power sockets – and lots of other plus and sockets!

Motors

Disk and hard drives have small brushed and unbrushed motors inside them. The easiest to remove and use



How's this for making a connection – stereo sockets, multi-pin DC plugs and sockets, IEC power sockets and more!



Four small motors that drive the CD tray and move the laser scanner. The ones pictured are only 25mm in diameter and 10mm thick. The large motor is a brushless type from a hard-disk drive

are the motors that drive the CD tray and move the laser – like the four shown here. These are very small motors – the ones pictured are only 25mm in diameter and 10mm thick! The larger one up the top is a brushless motor from a hard-disk drive.

Heatsinks

Inside a typical PC you'll find an excellent range of small to medium size heatsinks. As well as the fan-cooled heatsink on the main processor, you can often find smaller heatsinks on the motherboard. Inside the power supply is a range of heatsinks, from ones designed to work with three or four components to others designed for a single component. The thirteen heatsinks shown here were salvaged from just two PCs – and one of those PCs no longer had its main processor heatsink!

Also worth keeping are the insulating washers, insulating tabs and other hardware that you'll find holding components to heatsinks. They're just the sort of thing you often need but don't have in your parts collection!

Bits and pieces!

I can remember back in what seems like the dark ages when low voltage cooling fans were quite expensive. Well, that time is sure past now – these days, fans are free!

Also shown here (below right) are two fuses, three miniature pushbutton switches, already soldered to wires, three LEDs and a buzzer (again on wires), one mains power rocker switch, two mains power slide switches, and two large cable clamps/grommets.

Wire and cable

Always snip off and keep the power supply DC wires. Why? well, they're capable of handling more current than typical hook-up wire, are boldly colour-coded and come complete with plugs for which you can easily salvage sockets, while you're pulling the PC apart.

Inline sockets are also integrated into this cabling. If you need lighter gauge wires, the cables running to the LEDs and reset button usually fit the bill.

Bench Power Supply

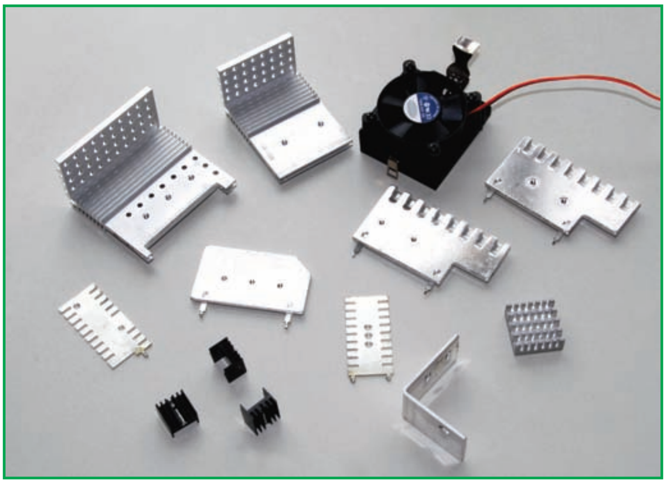
If you have a need for a 5V or 12V bench power supply, don't forget that it's easy to modify a PC power supply to provide this function. See last month's *Recycle It!* column.

Sheet metal

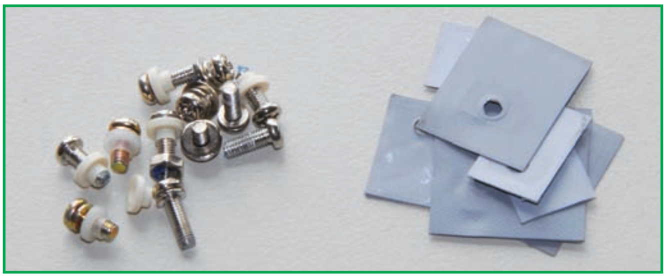
If you want to fold-up enclosures, make small brackets or need coated sheet metal for any other purpose, there's plenty available in the PC enclosure and the cases used around the disc drives. You can also use the whole PC enclosure as a large box, or gut the power supply and have a smallish fan-cooled box, complete with an IEC socket and (often) a mains power switch.

Hardware

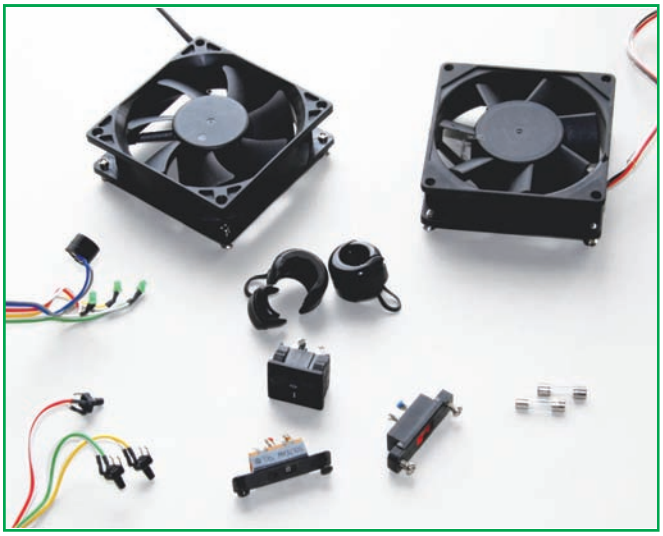
The amount of hardware quickly salvageable from a few PCs is amazing. Also, there are machine thread screws and self-tappers, threaded spacers, rubber grommets, springs, steel shafts, squishy plastic vibration absorbing mounts, and nuts and bolts. ***EPE***



Inside a typical PC you'll find an excellent range of heatsinks. As well as the fan-cooled heatsink on the processor, you may find smaller heatsinks on the motherboard



A collection of insulting brushes and insulating tabs/washers. Just the items you often need, but don't stock in your parts store



Two salvaged, and very useful cooling fans. Also seen here are two fuses, three miniature pushbutton switches (already soldered to connecting wires), three LEDs and a miniature buzzer, one mains rocker switch, two mains slide switches and two cable clamps/grommets

Circuit Surgery

Regular Clinic

By Ian Bell

Further aspects of total harmonic distortion (THD)

LAST month, in response to a question about measuring total harmonic distortion (THD) from frequent *EPE Chat Zone* contributor **741**, we looked at the theory leading to the definition of THD.

A few points from this discussion are summarised below, together with some further insights into the meaning of the terms distortion and THD. We will then continue to look at the definition of THD and related characteristics in more detail, and go on to look at the principles of measuring THD.

Distortion

In simple terms, distortion is a change in the shape of a waveform from what it should ideally be. For example, the shape of the waveform at the output of an ideal amplifier would be exactly the same as the input (but scaled up of course, due to the amplification). Similarly, a sinewave oscillator should produce a waveform with a perfect sine shape, and any deviation from this is distortion. However, not all changes of waveform shape are due to distortion. For example, a square wave input to an ideal low-pass filter may result in a 'rounded' square wave output; this is bandwidth limiting, not distortion.

In order to understand distortion we need to be aware of the set of frequencies present in our signals; that is their spectrum (plural: spectra). The only waveform for which the spectrum comprises just a single frequency is the sinewave (see Fig.1). Any other periodic waveform can be formed by adding together a set of sinewaves of various frequencies and different amplitudes. For example, a square wave may be described as having a frequency of 1kHz, but this is just the fundamental frequency; there are other frequencies present too. This is illustrated in Fig.2, which shows part of the spectrum of a square wave.

If a square wave is passed through an ideal low-pass filter, whose cut-off frequency is above the fundamental frequency of the square wave, then the higher frequency components of its spectrum will be reduced in amplitude (see Fig.3). The new spectrum will not contain any additional frequencies, but the different spectrum will result in a different waveform shape.

If a sinewave is passed through an ideal low-pass filter, whose cut-off frequency is above the sinewave frequency, the output spectrum will be unchanged. The output will still be a sinewave. However, if a sinewave is passed through a circuit which produces distortion, then additional frequency components will occur in the output spectrum (see Fig.4).

Distortion is caused by nonlinear circuits, which in simple terms means that their input-to-output voltage (or current) relationship is not a straight line graph. Circuits such as amplifiers, filters and data converts (DACs and ADCs) are usually meant to be linear. However, they deviate from this ideal for a variety of reasons, such as having limited maximum output voltage, which 'clips' large signals. Other circuits, such as comparators, are not meant to be linear and will, of course, intentionally distort waveforms. In general, we are only interested in distortion caused by the non-ideal behaviour of 'ideal' linear circuits, or in circuits or systems which should generate or convey pure sinewaves (this includes sinewave oscillators and mains power grids).

Harmonic distortion

Last month, we looked in detail at the theory which shows that a non-linear circuit with a single sinewave input will produce distortion containing only frequencies at harmonics (multiples) of the input (fundamental) frequency. This is known as harmonic distortion and leads to the definition of total harmonic distortion (THD). If the input signal contains more than one sinewave (more than one frequency in its spectrum) then the distortion produced is far more complex.

In order to meaningfully compare the amount of distortion produced by different circuits we need to have a widely applicable approach. THD (for amplifiers etc) is defined in terms of a single pure sinewave input signal. This definition of THD is applicable to other situations where single pure sinewaves should be present, such as sinewave oscillators and AC mains power supplies.

The definition of THD in words is: *the ratio of the root-sum-square value of the harmonic content of the voltage to the root mean square value of the fundamental voltage*. We can also define THD using the following formula, which we obtained from the theoretic analysis in last month's article:

$$THD = \frac{\sqrt{v_2^2 + v_3^2 + v_4^2 + \ldots}}{v_1}$$

in which v_1 is the RMS value of the fundamental and v_2, v_3 etc are the RMS values of the 2nd, 3rd etc harmonics (we defined RMS in last month's article). THD is usually specified as either as a percentage (by multiplying the above figure by 100) or as a decibel value:

$$THD_{\%} = \frac{\sqrt{v_2^2 + v_3^2 + v_4^2 + \ldots}}{v_1} \times 100\%$$

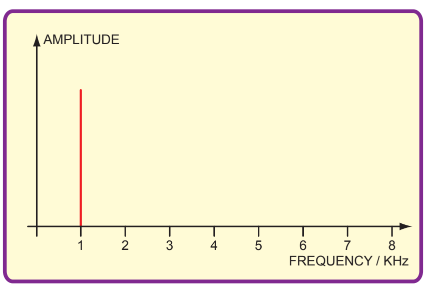


Fig.1. Spectrum of a 1kHz sinewave

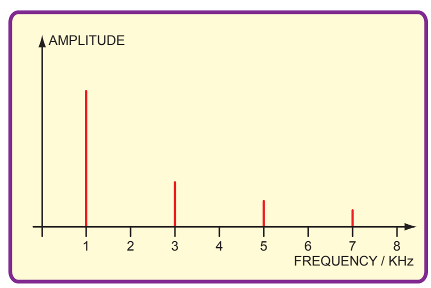


Fig.2. Part of the spectrum of a square wave with a 1kHz fundamental frequency

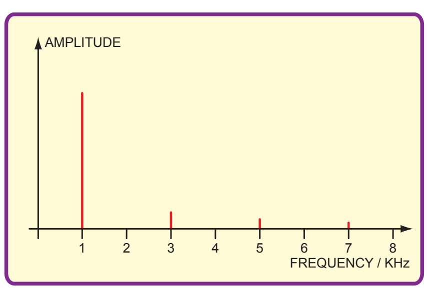


Fig.3. Part of the spectrum of a square wave from Fig.2 after low-pass filtering. There are no additional frequency components, but the relative amplitudes of the components have changed

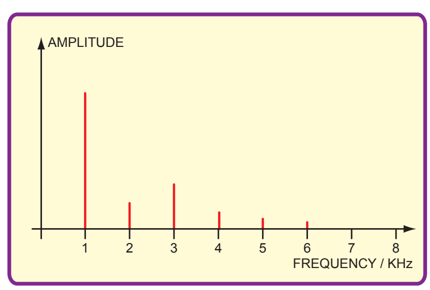


Fig.4. Spectrum of a sinewave after suffering distortion. There are now additional frequency components in the spectrum (compare with the perfect sinewave in Fig.1)

$$THD_{\mathrm{dB}} = 20\log\left[\frac{\sqrt{v_2^2+v_3^2+v_4^2+\ldots}}{v_1}\right]$$

As we stated last month, you may also see THD defined as a power ratio:

$$THD_{\mathrm{power}} = \frac{P_D}{P_1} = \frac{v_2^2+v_3^2+v_4^2+\ldots}{v_1^2}$$

where P_D is the total power in the distortion and P_1 is the power of the fundamental. Again, this can be expressed in decibels:

$$THD_{\mathrm{dB}} = 10\log\left[\frac{v_2^2+v_3^2+v_4^2+\ldots}{v_1^2}\right]$$

which will give same numerical THD_{dB} value as the previous formula. However, if THD is expressed as a percentage, the two definitions will give significantly different values. The voltage-based equation should be used as the basis for percentage THD measurements.

Noise

Distortion is not the only problem which afflicts our circuits. All circuits also produce, or introduce, a certain amount of noise across a wide range of frequencies. Therefore, a more realistic spectrum looks like the one shown in Fig.5. The level of noise in the spectrum is referred to as the noise floor. Signals below the noise floor cannot be distinguished simply by looking at the spectrum. For example, harmonics above the fourth in Fig.5 cannot be distinguished from the noise.

Measuring, detecting or using signals below the noise floor requires the use of special coding or signal processing techniques, for example those used in spread spectrum communications. Noise needs to be taken into account when measuring THD. Some distortion figures are, in fact, total harmonic distortion plus noise (denoted THD+N) and care should be taken about which quantity is being measured or stated.

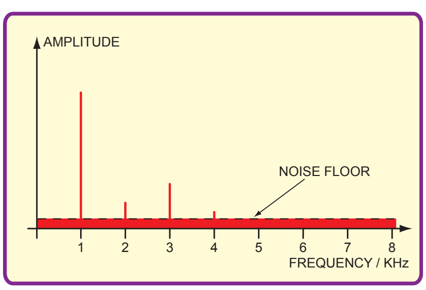


Fig.5. Part of the spectrum of a sine-wave after suffering distortion and noise. The noise has a broad spectrum and is present at all frequencies

As well as being important in 'low voltage' electronics, such as audio systems and radio receivers, THD is a significant issue in mains power supplies, particularly the supplies to large industrial plants and factories. If a load presented to the mains is non-linear (load changes with voltage), then the load current for a sinewave supply will not be sinusoidal – it will contain harmonics. Harmonic currents generated by non-linear loads can cause heating in motors and transformers, and failure of power factor correction capacitors. They may also cause problems for computer and control systems if mains filtering is inadequate. For mains supplies, total demand distortion (TDD) is often used instead of THD. This compares the distortion current to the maximum load current (over a given period), rather than the fundamental, because lower THD distortion at high load currents may have a worse impact than higher THD at low currents.

When measuring distortion the number of harmonics (v_2, v_3, v_4 ... etc) included in the measurement may vary depending on the approach used. Using a different number of harmonics may result in a different value of THD, at least until the harmonics disappear into the noise floor. Therefore, the number of harmonics used should be stated when giving THD measurements. Usually, no more than five or six harmonics are used.

The amount of distortion produced by a circuit will usually vary with signal amplitude. Most circuits will produce more distortion for large signal amplitudes as outputs come close to being limited by maximum voltages or currents. Some circuits will produce higher distortion at low signal levels too. For example, crossover distortion in power amplifiers may represent a larger proportion of the waveform at low output amplitudes.

The amount of distortion produced by a circuit will usually vary with signal frequency. All components and circuits have characteristics which are frequency-dependent to some extent, and we would therefore expect THD to be frequency-dependent too.

A frequency-related factor that is important in the distortion produced by some circuits is *slew rate*. This is the maximum rate of change (volts per second or amps per second) of the output that a circuit can produce. If a circuit cannot keep up with the rate of change required to follow the shape of the waveform it will simply ramp its output, with the voltage increasing or decreasing at the slew rate. In the worst case of slew rate limiting, a sinewave input will result in a triangle wave output. Slew rate problems become worse as both amplitude and frequency are increased.

Measuring distortion

THD measurements should have the signal frequency and amplitude stated. Ideally, THD should be measured and presented for the full range of frequencies processed by the circuit. For example, for an audio circuit, it is useful to measure THD over the 20Hz to 20kHz audio range. If a single figure is required, the worst case value over the full range can be given.

To measure distortion, you will need a sinewave oscillator (or a signal generator able to produce a good sinewave), unless, as was the case for 741, it is an oscillator you are trying to evaluate. For measuring distortion in amplifiers etc., the distortion produced by the oscillator is important, as it may be difficult to remove this from the measurement. As well as being low distortion, the frequency produced by the oscillator must be very stable, particularly if using filters in the THD measurement (which we will discuss later).

There are a number of ways in which THD can be measured. The best approach is to use a spectrum analyser, which may well have automated THD, THD+N and other distortion-related measurement built in. A spectrum analyser is a piece of equipment (or software) which will display the spectrum of its input signal, as a graph somewhat like Fig.1 to Fig.5. The amplitude of the signal and its harmonics can be read directly and hence the THD calculated (if it is not provided as a built in function).

Stand-alone spectrum analysers are rather expensive, and may be targeted at very high accuracy (very low distortion) or very high frequency measurements. However, for more modest requirements, basic PC-based oscilloscopes (for example from PicoScope, **www.picotech.com**) may include spectrum analyser software and be affordable by the hobbyist. As far as we are aware, the software provided with all PicoScope PC-based oscilloscopes (basic to high-end) includes a spectrum analyser with THD measurement.

For signals in the audio range, you may not even need a PC-based oscilloscope and oscillator to measure THD. With suitable software you could use a PC soundcard to generate the test signal and capture the output signal. Software could then provide spectrum analyser and THD measurement facilities. The range of frequencies that this could be used for will depend on the maximum sampling rate of the sound card.

Notch filter

Measurement of THD+N without a spectrum analyser is relatively straightforward in principle, but may be challenging in practice. In addition to a good quality sinewave oscillator you need a notch (narrow band-reject) filter at the same frequency as the oscillator (signal fundamental frequency). The notch filter removes the fundamental, so what remains is the noise and distortion; comparing this with the fundamental either as a percentage or dB value gives you your THD+N figure. This method measures THD+N, not THD, because the notch filter only removes the fundamental and the noise is included in the measured remainder.

The difficulty with the notch filter approach is that the filter has to be good enough to get useful results, and this may be difficult to achieve for low-distortion signals. The notch filter must provide very high attenuation at the fundamental frequency, but must not significantly attenuate the 2nd harmonic. The lower order harmonics (2nd and 3rd) are often the largest distortion components, so reducing these in the distortion signal will lead to potentially large errors.

The well-known passive twin-T notch filter is not good enough; its characteristic is too 'soft' and so it attenuates the 2nd harmonic too much. An active filter with a very sharp notch is required. The filter must be accurately tuned to the same frequency as the oscillator and both must remain stable during the measurement. This may be difficult to achieve if the notch filter has a very narrow stop-band, because it will only take a very small drift in either the oscillator or filter to take them out of alignment.

In order to measure low distortion signals accurately the notch filter must provide a lot of attenuation of the fundamental. Any signal at the fundamental frequency in the output of the filter will be included in the value of the distortion+noise signal and give erroneous results. For example, if the THD of the signal being measured is 0.1% or –60dB the notch filter must attenuate significantly more than 60dB at the fundamental frequency. Otherwise, the remaining fundamental will be of comparable magnitude to the distortion, and the measurement will indicate a larger THD+N than is actually present.

In conclusion, use of PC-based spectrum analysers is probably the best approach to measuring THD unless you can justify the expense of specialist test gear. We will look at using spectrum analysis in more detail in a future *Circuit Surgery*.

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

A Propeller-based Internet computer – Part 2

IN the last *PIC n' Mix* article (Aug '10) we took a look at an initial design for a video generation circuit based on the Parallax Propeller processor. Over the next few months we are going to grow the design into a multi-function Internet computer, but for now we need to take a close look at how we develop software for the Propeller processor, and how to download code onto it. Fortunately, it's a very simple process.

The Propeller is going to act as a stand-alone media co-processor in our final design, subservient to a more flexible PIC controller, and so we will not dedicate much coverage to it. It is, however, a very useful device and should prove to be invaluable in other designs, so we will cover it in sufficient detail to (hopefully) whet your appetite.

The software tools required to compile programs and download the software to the processor are, unsurprisingly, different to those used by Microchip. Fortunately, they are a fraction of the download size too, at 20MB (due to the simple fact that Parallax have a much smaller range of processors – one!). This makes them quicker to install, and easier to configure. Like Microchip's tools, they are completely free to download and use without any restrictions.

The compiler, editor and programming utility are combined in a single application called the 'Propeller Tool'. This is an 'integrated development environment' (IDE) much like MPLAB, except that it already contains all the software tools required in that single 20MB download.

No need for further downloads and messy installation steps to get a full development environment up and running – just download the file and run it to install everything required. No additional post-installation configuration is required, just download, install and run. Let's start by getting it installed.

Software installation

Start by visiting the Parallax website at: **www.parallax.com**. Click on the 'Downloads' tab, followed by 'Propeller Downloads' and then 'Propeller Software'. The Propeller Tool is the first download displayed – just click on the folder icon on the right-hand side. When the file has downloaded, run it and follow the installation instructions, allowing it to perform a full installation.

When completed, you will have two new icons on your desktop. Along with the Propeller tool, a simple serial terminal program is installed, which can be useful if you are using a serial interface between your Propeller system and the PC (although Hyperterm will work just as well and Teraterm is by far the best, but we won't be needing these.)

The download has also installed a user manual, processor data sheet and example schematic diagram, all viewable through the 'Help' option within the propeller tool, although you will need to have installed Adobe PDF reader to view these. There is also a large collection of well documented example libraries and demo source modules, which can be found in the directory 'C:\Program Files\Parallax Inc\Propeller Tool v1.2.7 (R2)\Examples\Library'.

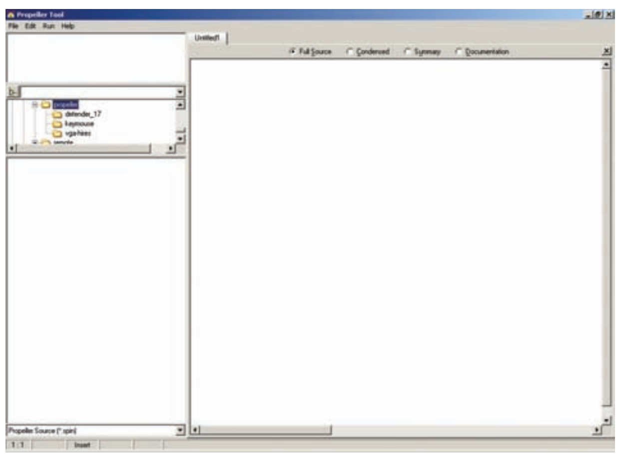


Fig.1 Initial startup screen

Starting up the Propeller tool reveals a very simple user interface (Fig.1). The large window on the right is the editor window, the windows on the left show the current directory, file list and in the top left, a project file hierarchy, which will at this point be empty.

To view an example demonstration project, use the directory window to navigate to the directory mentioned above, select 'Propeller Source (*.spin)' from the drop down list on the bottom left, and then double click on the file 'VGA_HiRes_Text_Demo.spin'. This will open the file in the main editor window.

The file is a demonstration program that will show, on a suitably equipped Propeller circuit and LCD monitor, the main features of the VGA monitor interface software. The program is very short, just two pages of text. The main functions are implemented in two library modules, 'VGA_HIRes_Text.spin' and 'Mouse.spin', which are located in the 'Propeller Tool v1.2.7 (R2)' directory. More on those in a minute.

The Propeller Tool has a concept called 'Top File', which is used to identify to the compiler that the selected file is the main application file. To identify the demo file as our top file, right click it in the file list on the left-hand window pane, and select 'Top Object File'. You can now compile the file to a format suitable for downloading to the processor by clicking 'Run' on the main menu, followed by 'Compile Top' and then 'View Info'.

The compilation process is very quick, and within just a second or two a dialog appears showing the amount of memory used, a view of the contents of the binary image created and options for transferring the image, either to a file or directly into the Propeller processor (Fig.2.).

There are two options for download to the processor; you can transfer it directly into the processor's RAM, or have the processor transfer the file into the attached EEPROM memory so that it will persist through a power cycle. Downloading to RAM is a useful technique for initial software development, as it reduces the time required in the usual debugging cycle of edit-compile-download-test, making software development a joy, without the usual slow programming times.

Saving the program to a file will have its uses later on, as we will be building a PIC-based control system that can dynamically load new firmware onto the Propeller through its serial interface. This will come in handy when we provide support for different resolution displays. For now, we will be sticking with a resolution of 1024 × 768 pixels.

Testing the hardware

Let's test this out on the hardware we created in the previous *PIC n' Mix*. Power up the main circuit board from a 5V regulated power supply, and connect the serial interface board to it, connecting the DB9 connector of the serial board to your PC's serial port, or via a USB-to-Serial adaptor. In the Propeller Tool, click on the 'Load EEPROM' button, and your file should be quickly downloaded to the PCB's EEPROM chip. If you receive an error message then you should first check your serial connection (using USB? Did the driver install correctly?) and then check the wiring between the two circuits.

Assuming all is well, the next stage is to test the output of the board on an LCD monitor. Disconnect the serial interface and power, connect the main circuit board

to an LCD monitor and then restore the power to the board. Within a few seconds, the LCD should sync with the signal and display a colourful screenfull of text.

Take a close look at the edges of the screen; the characters should be crisp and stable. Now take a moment to marvel at the simplicity of the circuit that is generating the picture, and allow your mind to consider for a few minutes, the opportunities that this presents for some new projects!

Back to the software

At this point, we have proved that the hardware, simple as it is, is functional and driving an LCD correctly at a resolution of 1024 × 768 pixels, and yielding a useful display area of 128 × 64 characters in a variety of colours. Memory limitations mean that we will be unable to display complex graphics images, and for this reason our project will limit itself to text-based applications such as email, instant messaging, Facebook updates and Twitter (where my kids spend most of their time. Email, apparently, is only for old people.)

It may come as some surprise to you that this software works with our hardware design; it's actually intentional, as we based our hardware around a standard pinout used by many of the library functions.

All of the software libraries and demonstration applications supplied are issued under a free licence and can be used for any purpose, personal or commercial. The software supplied is a small subset of a much larger, still freely available collection issued under the 'Propeller Object Exchange' section of the Parallax website. There are thousands of downloads available, and a useful download counter display indicates the more popular ones. Well worth taking a look.

We will be using several library modules in our application; a keyboard and mouse interface, and stereo sound output. Even with all these features there will still be spare memory and I/O available for future enhancements.

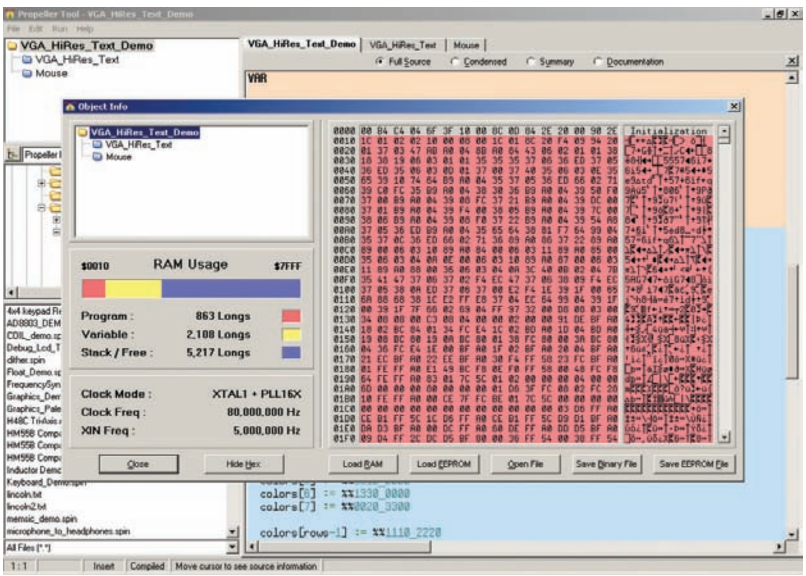


Fig.2 Compilation complete screen

A quick word about Spin

If you look at the contents of the VGA_HiRes_Text source file you will see that it is a mix of a strange high level language, called Spin, and some assembly language. Spin is an interpreted language, not unlike BASIC, and has been specifically developed by Parallax for the Propeller processor. Unlike BASIC, it is a very efficient language, and runs at approximately one fifth of the speed of assembly. This is a major achievement and makes it very suitable for even the most intensive applications, leaving just a few time-critical functions requiring assembly language constructs.

The majority of the software we will be running on the Propeller processor will be existing library functions, and so we will not delve into the Spin language for this article series, but we recommend that you take some time to examine the tutorials and manual for the Propeller. It's a very interesting device.

That's all for now. Next month, we will look at improving the circuit to connect a keyboard and mouse, and start preparing for the connection to the PIC microcontroller. Until then, why not tinker with the VGA_HiRes_Text_Demo source code and try creating some different screen displays? If you make a mistake, you can always re-install the software.

Compact Control Design

Electronics and Software design

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MonCon485

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10 slot back plane with boards installed

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8 channel REED relay board (left), 8 channel POWER relay board (right), 8 channel MAINS relay board coming soon.
LED status indicators for each relay. Industry standard connectors used. Pre-programmed commands to turn on/off single relay, groups of relays, toggle and pulse relays.

8 channel opto isolated I/O board (left). Each channel can be input or output (specify when ordering). Opto inputs support AC or DC signals 5V to 24V. LED indicators for status of each channel. Pre-programmed commands to turn on/off, pulse or toggle outputs, inputs can trigger events, switch outputs etc.

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- Stepper motor controller. 25 pin D type for motor outputs, home, limit, encoder inputs. Uses Allegro A3980 automotive stepper IC. 1Amp max. 35V max, over temp. and short circuit protected. Stepper position (trapezoidal) and precision speed control firmware.
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Check the web site for details

By Robert Penfold

INTERFACE

Expanding the number of output lines

As pointed out in a previous *Interface* article, there can be problems with a missing bit when using serial interfacing with a PC. The problem is that the most significant bit (bit 7) is always set at zero, making it impossible to transfer values of more than 127 (decimal).

Whether the serial port is the genuine article or a pseudo type on a USB port seems to be irrelevant. It can occur with either type, and is not a result of a flaw in USB serial ports interfaces.

Taking control

This hitch is not anything new, although I do not remember any problems of this type in the very early days of PCs when using GW BASIC or an assembler and the MS-DOS operating system. However, it has sometimes been a problem with Visual BASIC and various versions of Windows.

Strangely, it could occur when using Visual BASIC and direct control of conventional serial port hardware. On the face of it, this method of serial interfacing should be completely free of any hitches provided the serial chip is set up correctly, but in practice it is often problematic.

With Visual BASIC 6 it was possible to use serial interfacing via an ActiveX component called MSCOMM32.OCX, which was provided as part of the more expensive editions of Visual BASIC 6. There were a few difficulties when using this component, but it could provide serial communications with the full eight bits of data.

Unfortunately, this component was not supplied with the first .NET version of Visual BASIC, which was the one that superseded version 6. In fact, there was no built-in serial component of any kind supplied with the original .NET version of visual BASIC. Using the serial or parallel ports was only possible with the aid of third-party add-ons.

For reasons that have never been clear, using the MSCOMM32.OSX with the .NET version of Visual BASIC was not possible. Trying to add the MSCOMM32.OSX component to a project produced an error message to the effect that the user was not licensed to use it. There were suggestions on some Internet forums that this could be avoided if a suitably upmarket edition of Visual BASIC 6 was installed on the computer together with the .NET version.

However, this was the setup that I was using at the time, and it did not make any difference. The .NET version of Visual BASIC still refused to use MSCOMM32.OCX.

Compatible, but…

I am grateful to ***David Sims*** for pointing out that Microsoft has now had a 'change of heart', and MCCOMM32.OCX can be used with the latest versions of Visual BASIC, including Visual BASIC Express 2010.

The original .NET version of Visual BASIC received a great deal of criticism due to its poor compatibility with earlier editions, and its inability to handle some tasks that were within the compass of Visual BASIC 6. Microsoft has improved compatibility in recent versions of Visual BASIC, and adding compatibility with the MSCOMM32.OCX component is presumably part of this process.

As pointed out previously, an advantage of using MSCOMM32.OCX is that it does not suffer from the problem of the most significant bit being locked at zero. Provided an 8-bit word format is used, full 8-bit operation will be obtained.

However, there is a major drawback that has to be borne in mind when using this component, whether it is with Visual BASIC 6 or the 2010 version. It works fine under Windows XP, but it is not properly compatible with Windows Vista or 7.

Although users of MSCOMM32.OCX might find that it works well with their current setup, any software that uses it is doomed to failure if the operating system is upgraded to a recent version of Windows. It should also be borne in mind that there is no point in supplying software that utilises MSCOMM32.OCX to anyone using Windows Vista or 7, as it will not work in a worthwhile fashion under these operating systems.

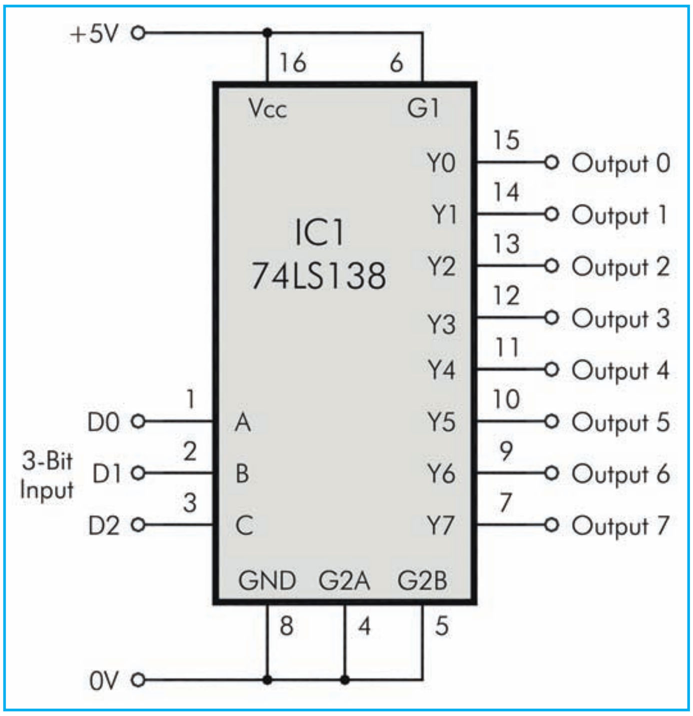

Fig.1. The 74LS138 is a 3- to 8-line decoder, with seven outputs that are high and one output that is low. The output that is low is governed by the binary code on the 3-bit input

Quart out of a pint pot

Whether a serial port provides a 7-bit input/output port or an 8-bit type, for many practical applications it will either be necessary to find a way of expanding the number of inputs and outputs, or those that are available must be used in an efficient manner. Expanding the number of inputs and outputs is not actually that difficult, and it became even easier with the advent of inexpensive microcontrollers.

The usual approach is to have (say) three 8-bit output ports, with the data for these ports always sent in groups of three bytes. The microcontroller then directs each byte of data to the appropriate one of its three output ports. In practice, it is usually desirable to include safeguards to ensure that the system cannot get out of synchronisation, and that each byte of data is always sent to the right port.

There is more than one way of achieving this, and a very simple approach is to have the microcontroller programmed to wait for three bytes in rapid succession. The data is discarded if there is an excessive gap between any of the bytes, which is likely to mean that the group of three is actually two bytes from one group and one byte from the previous group.

A more sophisticated approach is to have the data bytes framed by code bytes. Data is again discarded unless it is received in the correct form, which in this case would be one or more bytes containing the start code, the three data bytes, and then one or more bytes containing the stop code.

With a system of this type, it does not matter too much if the hardware can only handle seven bits at a time. The data is often sent in the form of ASCII codes, with the encoding into ASCII and the decoding back into numeric data being handled quite easily in the software running on the PC and the

microcontroller. This seems to be the approach normally used with commercial robotic systems, etc., that use serial interfacing. Another approach is to send data in 4-bit nibbles, with higher values being reserved for control codes.

An obvious drawback of a system that sends groups of bytes in serial form is that it is relatively slow. It is also inefficient in that all the ports have to be updated, even if there is only fresh data for one port. Serial interfacing is not particularly fast anyway, so this method of interfacing is unlikely to be used in an application that requires high-speed transfers.

In cases where sending bytes in serial form would slow things down to an unacceptable degree, it is worth considering the alternative approach of using two or three virtual serial ports on separate USB ports. Most PCs have spare USB ports, and more ports can be added quite cheaply using an add-on hub.

Line decoders

It is not always necessary to use a microcontroller in order to effectively expand the number of output lines. Some applications require something like eight output lines, but only one line at a time will actually be set to the active state. This makes inefficient use of an 8-bit output port because only eight of the available 256 binary values will ever be used.

A simple solution is to use an eight line decoder chip, such as the 74LS138. This has a 3-bit binary input port and eight output lines, numbered from 0 to 7. Placing a binary value on the inputs results in the appropriate output going low (logic 0).

This enables eight outputs to be controlled from three input lines, with the obvious proviso that it is not possible to have more than one line at logic 0. Perhaps less obviously, there is no option of having all the outputs high (logic 1), since writing a value of zero to the inputs results in output 0 going low. However, by ignoring output 0 it is possible to have seven outputs plus an off state.

There is a slight complication in that there are two negative enable inputs (pins 4 and 5) and a positive enable input at pin 6. These must be connected to the relevant supply rails in order to switch on the output section of the device. Fig.1 shows the basic circuit for a 74LS138 as a 3- to 8-line decoder. The 74LS138 has a standard 16-pin DIL encapsulation.

The 74154 line decoder provides 4 to 16 line decoding, and is similar in operation to the 74LS138. It lacks a positive enable input, but two negative enable inputs (pins 18 and 19) are included. The basic circuit for a 4- to 16-line decoder using a 74154 is shown in Fig.2. This chip has a 24-pin DIL encapsulation with the wider (0.6-inch) row spacing.

Quart into a pint pot

It is possible to do things the other way round with a few inputs monitoring numerous input lines, but there is a practical drawback with a system of this type in most real-world applications. You could have a setup where, for example, eight sensor switches were monitored using three input lines and a suitable encoder circuit. One of the inputs going low would result in the appropriate binary value for that input appearing on the three output lines. In other words, the decoder circuit would be like a 74LS138 in reverse.

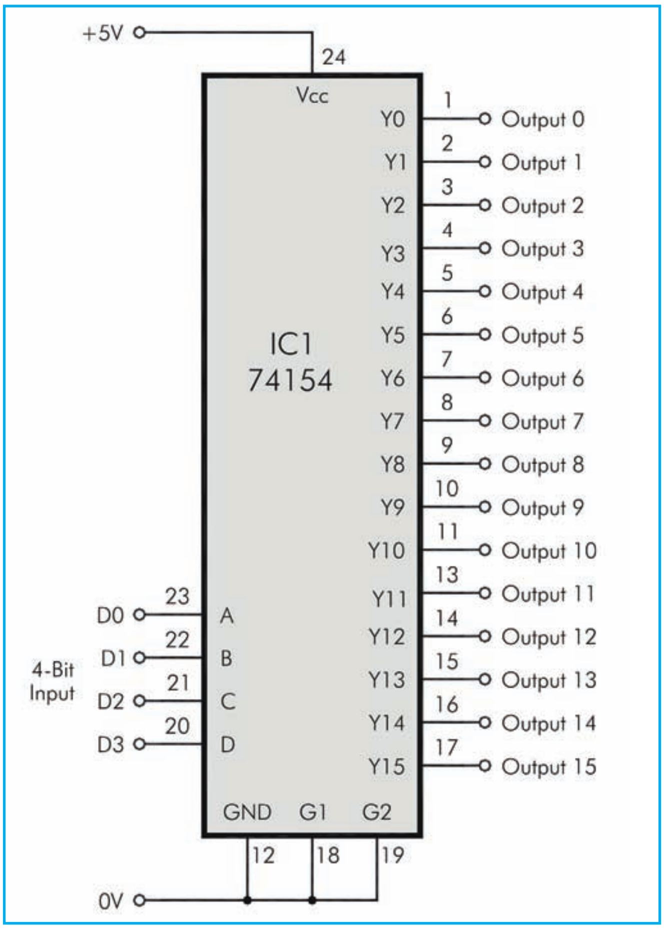

Fig.2. The 74154 is a 4- to 16-line decoder that is similar in operation to the 74LS138. Like the 74LS138, the outputs are normally high and the active output is low

The problem with an arrangement of this type in most practical applications is that the sensors might not conveniently take it in turns to activate the decoder. More than one sensor might be active at any one time, and the decoder would not be able to handle this properly.

In an application of this type, an 'intelligent' decoder based on a microcontroller is a better option. The microcontroller could scan the inputs. If any were found to be active it would then output the appropriate binary values. The microcontroller would also control the serial interface, and would ensure that each value was sent to the PC.

Of course, in some applications it is merely necessary to detect that a sensor has been activated, and it does not matter which particular one has been triggered. This type of thing does not require any complex electronics. Any number of sensors can be monitored using a single digital input and an OR gate that has the appropriate number of inputs.

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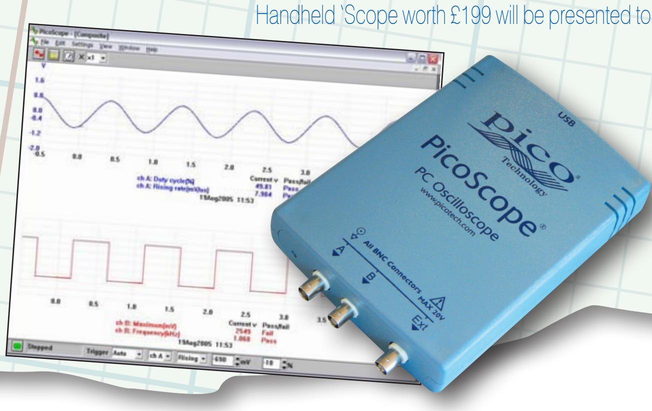

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Experimenter's All-Band Radio – *radio without tears*

MANY years ago, the author designed an *All-Band Radio* which was featured as a constructional project in *EPE*. The design did not end there, however. The author continued to develop it and tweak it over the years, until it reached the form shown here.

The circuit diagram shown in Fig.1 might be described as an 'AM radio without tears'. It is a robust little radio that should work no matter what – with virtually any tuned circuit, any aerial (or none at all), and without the need for an earth wire. It has good sensitivity, good selectivity, and modest power into a 1W RMS loudspeaker – or good power into headphones. While sound quality is modest, the circuit may be unmatched for economy and simplicity.

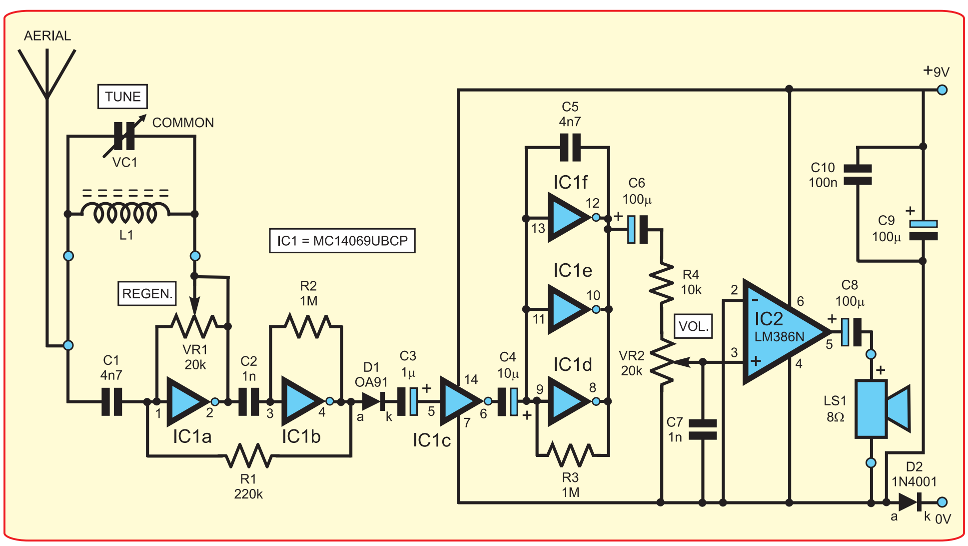

Fig.1. Experimenter's All-Band Radio

At the core of the circuit (Fig.1) is IC1, which serves both as receiver and preamplifier. Being a 4000-series CMOS IC, it is capable of operating (in theory) up to 5MHz, and in practice well above this. Therefore, the radio has a wide coverage – being capable of receiving long waves (LW) through to the short wave (SW) 41-metre band. Since this is a regenerative receiver, it will also (potentially) pick up single-sideband transmissions (SSB).

This type of radio is regenerative – a personal favourite of the author. Simply described, instead of having volume and tuning dials only, it has volume, tuning, and regeneration dials, which leads to a fascinating balancing act in practice.

Circuit details

At the heart of the circuit lies an unbuffered hex inverter, IC1. Although this is classed as a digital device, it may in some situations serve as an analogue amplifier up to several megahertz. The circuit has been specifically designed around the Motorola MC14069UBCP inverter IC, and this is the device which should be used for best results. Equivalents might disappoint.

When a station is tuned in, VC1 and L1 resonate at the tuned frequency. In other words, they present a miniscule alternating voltage to the input of IC1a through DC-blocking capacitor C1. Therefore, any activity in the tuned circuit unsettles both the input and the output of IC1a, sending ripples down the chain IC1a to IC1f, which are amplified and demodulated as they go.

The input of a 4069 inverter gate is typically biased at around half the supply

voltage, and this bias may be stabilised by adding a feedback resistor such as R2, so that the output and input equalise. The greater the value of the feedback resistor, the more sensitive the input will be.

To bring about regeneration, the tuned circuit is inserted in the feedback path of IC1a. The higher the value of VR1, the greater IC1a's potential for 'being unsettled', and the greater the regeneration as the amplified signal is passed back to input pin 1 through the tuned circuit via output pin 2. Further regeneration is provided through resistor R1, so that regeneration in this circuit occurs through two paths simultaneously, namely through the tuned circuit itself, and through R1.

The purpose of regeneration is to reinforce the RF signal through positive feedback. Not only does this amplify the signal, but it also sharpens it a great deal.

Inveter gate IC1b serves to amplify the radio frequency (RF) signal, which is fed back to IC1a through R1 to provide the additional regeneration. Resistor R2 stabilises IC1b and manages its gain. Diode D1 provides demodulation (that is, it extracts the audio signal), while capacitor C3 couples IC1b to IC1c.

A common disadvantage of using a simple diode for demodulation is that this may kill weaker signals through its voltage drop. Therefore, before demodulation is applied to this circuit, RF amplifier stage IC1b is added.

IC1c, which is wired as a simple buffer, further amplifies the signal. By omitting any feedback components here, this prevents any destabilisation of the radio circuit through feedback from the 'power' section. IC1d to IC1f are paralleled to provide maximum current for the amplifier IC. Capacitor C5 serves as a low-pass filter, and improves the tone of the radio. In fact, when using headphones, the tone is excellent and 'full-bodied'.

Finally, amplification is provided through a well known amplifier IC, the LM386N. Amplifier volume is controlled through rotary potentiometer VR2.

The radio draws 20mA to 30mA current, which should see it through about two days and nights continuous use off a 9V AA battery pack. Note that the radio will take a few seconds to come to life after switch-on. This should be heard by a hiss appearing in the loudspeaker.

Tuned circuit and aerial

The most commonly available AM tuners (variable capacitors), typically have two separate sections or gangs (that is, two variable capacitors with one common terminal). A tuned circuit for the medium waves could use such a tuner with its two separate sections wired in parallel.

Either a ready-made medium wave coil may be used for L1, or this may be wound with 80 to 100 turns of approx. 30swg (0.315mm) enamelled copper wire, close-wound on a 10mm diameter ferrite rod.

Both VC1 and L1 may be pulled out of an old radio set. Don't hesitate to wire up different coils and variable capacitors (AM tuners) to see what the circuit does with them. Also, try experimenting with different aerials, which could greatly increase the range of the radio. It should be possible to pick up many distant stations at night (but not during the day – for example, *Deutsche Welle*, or *Radio China* – by winding a length of enamelled copper wire a few times around a room. Also, burglar bars or even a tree may serve reasonably well as an aerial.

In order to access higher frequencies, thicker gauges of wire should be used for coil L1, with fewer turns, spaced out more widely on the ferrite rod, or even being air spaced. For example, the 41-metre shortwave band may be accessed with an air spaced coil wound on a 25mm diameter former, comprising 10 turns of 24swg (0.56mm) enamelled copper wire. This is then stretched out to 25mm from end to end.

When using the radio, regeneration needs to be held as high as possible without introducing excessive feedback to the circuit. Excessive feedback is manifested either through 'juddering' or 'shrieks' in the loudspeaker or headphones – or by the circuit going completely 'dead' (this will not harm the circuit).

Generally speaking, Regeneration control VR1 will need to be adjusted to about half its value. Volume control VR2 will need to be turned up as high as it will go without excessive distortion.

Much depends on the length of the aerial, and on signal strength. On the higher shortwave bands in particular, regeneration will need to be turned up full, and the values of VR1 and R1 might even be altered. The value of resistor R1 may be reduced (eg, to 100k for more radical regeneration), or R1 could be replaced with a 500kΩ preset potentiometer for greater flexibility in experimenting.

To put it simply, a regenerative radio requires a careful balance of *all* the controls for best reception, and a good deal of experimentation may be required to get the best out of it.

Happy listening!

Thomas Scarborough,
Cape Town, South Africa

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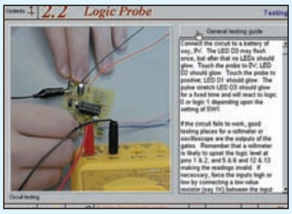
ELECTRONIC PROJECTS



Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

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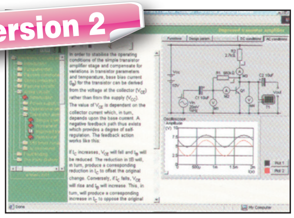
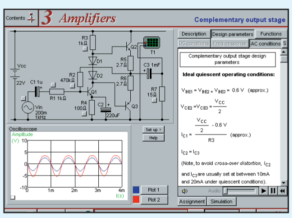
Version 2


Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits. Active Circuits***. *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS



Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: ***Fundamentals*** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections). ***Op Amps*** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. ***Amplifiers*** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). ***Filters*** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). ***Oscillators*** – 6 sections from Positive Feedback to Crystal Oscillators. ***Systems*** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

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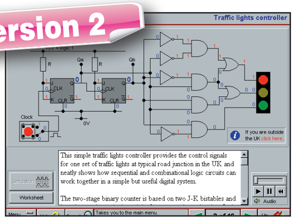
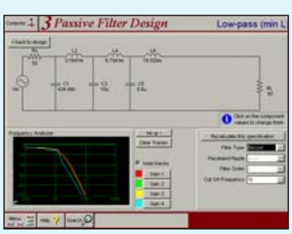


Virtual laboratory - Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

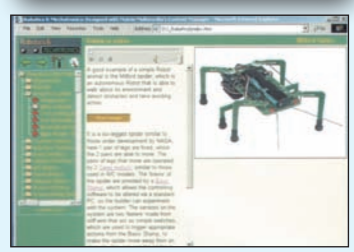
ANALOGUE FILTERS



Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters. This CD-ROM is being discontinued, **only the Hobbyist/Student version is now available**.

ROBOTICS & MECHATRONICS


Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	**£45**	**inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99**	**plus VAT**
Institutional 10 user (Network Licence)	**£249**	**plus VAT**
Site licence	**£499**	**plus VAT**

(UK and EU customers add VAT at 17.5% to 'plus VAT' prices)

PICmicro TUTORIALS AND PROGRAMMING

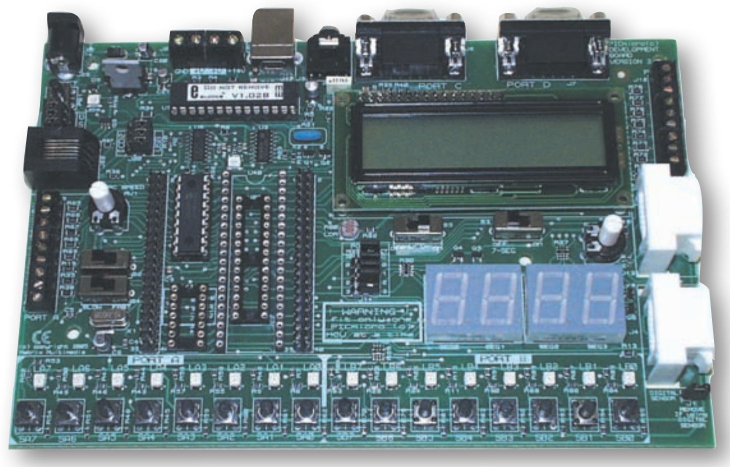
HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual LEDs, quad 7-segment display and alphanumeric LCD display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)



£158 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

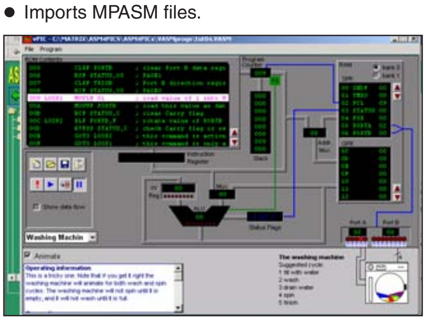
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

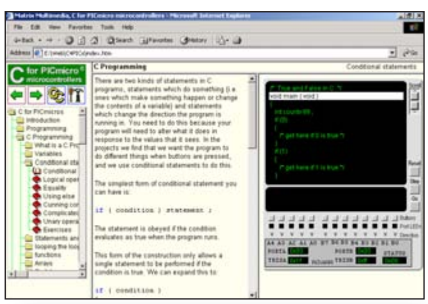


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



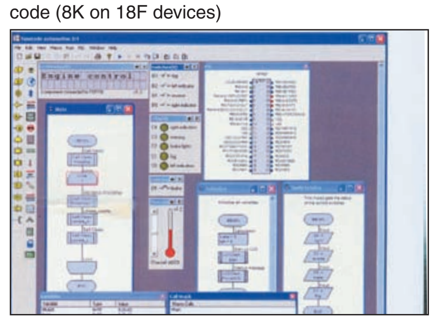
Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

- Requires no programming experience
- Allows complex PICmicro applications to be designed quickly
- Uses international standard flow chart symbols
- Full on-screen simulation allows debugging and speeds up the development process.
- Facilitates learning via a full suite of demonstration tutorials
- Produces ASM code for a range of 18, 28 and 40-pin devices
- 16-bit arithmetic strings and string manipulation
- Pulse width modulation
- I2C.

New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



PRICES

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Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional/Professional 10 user (Network Licence)	£350	plus VAT
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Flowcode Institutional (Schools/HE/FE/Industry)	£149	plus VAT
Flowcode 10 user (Network Licence)	£399	plus VAT
Flowcode Site Licence	£799	plus VAT

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TINA Pro V7 (Basic) + Flowcode V3 (Hobbyist/Student)

TINA Analogue, Digital, Symbolic, RF, MCU and Mixed-Mode Circuit Simulation, Testing and PCB Design

£68.00 inc. VAT and p&p

TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

Customise presentations using TINA's advanced drawing tools to control text, fonts, axes, line width, colour and layout. You can create, and print documents directly inside TINA or cut and paste your results into your favourite word- procesing or DTP package.

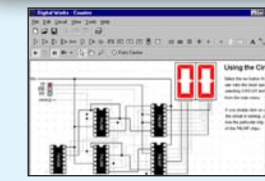
TINA includes the following Virtual Instruments: Oscilloscope, Function Generator, Multimeter, Signal Analyser/Bode Plotter, Network Analyser, Spectrum Analyser, Logic Analyser, Digital Signal Generator, XY Recorder.

***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

Get TINA + Flowcode for a total of just £68, including VAT and postage.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

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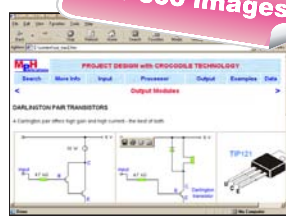

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All circuits can be viewed, but can only be simulated if your computer has Crocodile Technoloy version 410 or later. A free trial version of Crocodile Technology can be downloaded from: **www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.*

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☐ 'C' for 16 Series PICmicro V4
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Max's Cool Beans

By Max The Magnificent

So little time...

AS I pen these words, I have recently arrived back from Bangalore, India, where I was speaking at the *Embedded Systems Conference* (ESC). This was an experience I will never forget. The day before the conference I meandered my way over to the convention centre to make sure I knew where everything was and also that my computer would work with their audio-visual equipment.

I took a taxi, of course. Visitors would have to be insane to try to drive on Indian roads themselves. Indeed, most of the drivers over there do appear to be insane. No one pays any attention to lanes, so you get at least three or four cars occupying the pair of lanes going in your direction, with the same number racing toward you on the other side of the road. Everyone is peeping their horn to let you know they are there, so you travel in a cacophony of sound.

Along with the regular cars there are thousands upon thousands of little 'auto rickshaws' zipping around. These are small, yellow vehicles with lawnmower-sized engines, a wrap-over roof, open sides, and – just behind the driver – seats for two passengers who are either very close friends or they will be by the end of their journey. Also, there are a multitude of motorbikes and motor scooters threading their way back and forth between the lanes of traffic competing for any small advantage. Usually, there are at least two people on every bike or scooter; ladies ride 'side saddle' on the back, or any male passenger tends to be holding something large and unwieldy – like a huge glass window – over his head (I kid you not).

When I arrived at the convention centre I discover that my first presentation – which was to take place the following day from 10:00am to 6:00pm (with breaks, of course) – was to be held in a huge auditorium. This was much bigger than I'd expected – the size of a medium-sized cinema – in fact it even had an upper balcony. I must admit to being a little intimidated, but everything ended up going really well, and the attendees stayed after the main presentation, asking questions until at least 6:45pm (which either means that they really enjoyed themselves or they didn't have a clue what I was waffling on about).

As for the food – it was magnificent. I had one day free from speaking in the middle of the conference, so two of the other speakers and I went for a wander around to purchase presents for our wives (there would be no point in my returning home without gifts ... it would be simpler to run away). During our shopping expedition, we broke for lunch at what I can only describe as an Indian interpretation of a fast food restaurant.

After queuing for a few minutes we were guided to a table. As soon as we were sitting, someone zipped past depositing individual metal trays in front of us. Someone else raced past and placed seven small and one medium-sized metal dishes on our trays. Then other waiters appeared from all directions, filling the various dishes with different foodstuffs, drizzling sauces hither and thither, and tempting us with a variety of different breads. As soon as I emptied a bowl it was refilled, so I'd put on about 20 pounds before I discovered that you had to turn a dish over when you'd had enough.

English rules

But that's not what I wanted to talk to you about... Do you recall a couple of columns ago when I was waffling on about grammar and punctuation and the difference between things like 'its' and 'it's', 'your' and 'you're', and 'there', 'there're', and 'their'? As fate would have it (and I find this hard to believe myself as I pen these words), I've recently developed quite an interest in grammar and punctuation and related topics.

For example, I just ran across a nugget of trivia that the plural of 'octopus' should be 'octopuses' or 'octopodes', you really shouldn't use 'octopi' (even though a lot of folks do). Why? Well, it seems that '-us' changes to '-i' in plurals only for second declension Latin nouns, but 'octopus' comes from the Greek.

The point is that when you really start to look at English grammar, it doesn't take long before you come to the conclusion that things are really rather complicated – much more so than they really need to be. Of course, one of the problems is that what we call 'English' is actually composed of elements from many different languages. First we had the Celtic branch of Indo-European circa 1000 BC. Then the Romans started to raid England, starting in 55 BC, leading to a full-blown occupation in 43 AD, at which time the Roman colony of 'Britannia' was established and Latin started to be spoken by the educated classes.

Following the Roman departure from England early in the 5th century, a variety of Germanic tribes arrived in England (Angles, Saxons, Jutes, and some Frisians). A few hundred years later, the Vikings started to attack England, resulting in England being partitioned in 878 into a part governed by the Anglo-Saxons and a part governed by the Scandinavians (Vikings). Later, in 1066 AD, the French-speaking Normans invaded England, after which things started to get complicated.

The end result is that 'English' is a complete mish-mash of many languages. And just to make life even more interesting, Latin continued to be the *lingua franca* of educated peoples in England and around the world. All of which brings us to the fact that the rules of English grammar were originally modelled on those of Latin. In fact, would you believe that the very first book on English grammar was written in Latin!

And when you were at high school you wondered why English grammar was so complicated. The problem is that Latin and English are two totally separate languages, so taking the grammatical rules from one language and applying them to another is bound to cause problems. As Bill Bryson says in his book *The Mother Tongue (English and how it got that way)*:

'Imposing latin rules on English structure is a little like trying to play baseball in ice skates. The two simply don't match.'

I've always wondered how it is that a very small number of words in Latin can convey so much information. Consider, for example, the famous quote by Julius Caesar: *Veni, vidi, vici* (I came, I saw, I conquered). One of the reasons Latin is so succinct is that, in Latin, verbs can have anywhere up to 120 inflections; by comparison, in English a verb never has more than five (eg, see, sees, saw, seeing, and seen) and often only three or four.

Fortunately, I have discovered a useful short cut that allows me to gainfully drop Latin phrases into the conversation without learning the language. This secret tool is the book *Latin for all Occasions* by Henry Beard. This little scamp is a treasure trove of information, jam-packed with hundreds of useful phrases.

READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

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☆ LETTER OF THE MONTH ☆

Stripboard revitalised with CAD

Dear Editor

I read with much interest Harry Mellor's letter *Stripboard projects please* in the August 2010 issue. I found myself nodding in agreement with all the points he made; yet I also found myself in agreement with all your points in response. I suspect that like Harry, I grew up and started messing about with electronics in an era when stripboard was just beginning to make its mark.

Most of the projects I make today are still prototyped on stripboard, simply because by now I have gotten pretty good at knocking things together quickly with it (I find 'breadboarding' isn't my thing). If the project then works as planned, I either make a printed circuit board or use VeeCAD to make a stripboard layout (more about this below). Because I normally end up changing things about quite a bit before finalising my projects, it is far cheaper for me to 'waste' a bit of stripboard rather than the much-more-expensive photo-resistant Riston board I use for making my PCBs.

It is interesting the way things turn out; I recently won an online auction for a bundle of 'old electronics magazines'. When I received them I was stunned to find issue number one and two of *Everyday Electronics*. Coincidentally, the very first *EE* was issued with a piece of stripboard as a 'free gift', which was then used for a few subsequent projects. This was a real bonus for my collection of (now vintage) magazines, though sadly, the original stripboard did not come with it. Since many of those early *EE* projects still used matrix board or tag strips, the free stripboard would have been a valuable freebie and it is interesting to read the reader's letters of the time praising the stripboard and how revolutionary it was!

As for VeeCAD, it's like other PCB/CAD software except a stripboard layout is generated instead of a PCB layout. VeeCAD imports netlists in most popular formats, therefore no matter what schematic editor you use, you can export the netlist to VeeCAD. That said, it is also designed to work hand-in-hand with a freeware schematic editor named TinyCAD, and to this end, specially designed TinyCAD libraries are included with VeeCAD.

This makes a great starting point for those interested in going further than they ever thought possible with stripboard. It also doesn't break the bank, since TinyCAD is freeware and even though VeeCAD is shareware, it is very reasonably priced compared to other PCB-type software, while a freeware feature-limited version is also available.

So it seems these days we can have the best of both worlds; with the right software one can easily produce complex stripboard layouts for everything from PIC-based circuits to whatever they can dream up in their schematic editors.

I should add that I have no affiliation or other relationship with any of the software vendors mentioned, I am just a happy user

Dave Thompson, New Zealand, By email

It is excellent news that stripboard is being supported by the CAD fraternity, and long may it continue. I am delighted to hear about your online auction 'coup'! Old electronics magazines are a fascinating combination of wonderfully antiquated circuits, and at the same time a reminder that good design never goes out of fashion. The ingenuity with which designers produced impressive projects using a 'limited' choice of components is truly inspiring.

Real radio

Dear Editor

I would like to suggest a couple of ideas for possible projects for *EPE*.

First, a 50W stereo amplifier plus car power supply. This would be a 2N3055/MJ2955 power amplifier stereo pair, with an impressive specification – basically a classic standard circuit with optimised frequency compensation, giving typically 0.01% distortion at 20kHz for 8Ω speakers, and worthwhile in its own right. Plus, a switching power supply based on a driven converter using MOSFETs/ferrite core to provide ±33V from a 12V supply to run a car stereo system with the amplifiers

Second, a design for a 'proper' FM radio receiver. This would be a 'retro' radio, designed to show that FM tuners can still be built using homemade coils. I have a design, but I've not yet not built and tested it. This project is intended to support the 'keep the FM analogue' movement, as well as providing a demonstration (if it works) of home construction. I plan to build this fairly soon, and will advise if/when it is working.

My aim is to provide stereo and use FETs in the RF stages, primarily because these are widely available, while many of the more 'traditional' transistors used in the past have become obsolete.

For me, modern FM radio chips miss the point – if you were to use chips, you may as well just buy a small FM radio!

John Ellis, by email

Thank you John, these do sound like exciting projects and I hope you will keep us informed of your progress. You, and other readers, may be interested to know about a sister publication to EPE, *called* Radio Bygones. *It covers the kind of 'real' radio technology you appreciate and is published by Wimborne six times a year. Oh, and by the way, I agree that FM radio should be preserved, to my ears it sounds much better than DAB, but then I like vinyl too.*

Snacking on SMDs

Dear Editor

I found the article on soldering SMDs very interesting, especially since I have been through similar experiments as the author, and reached the same conclusion of using a snack oven.

One point I noticed during a number of temperature runs with the oven was that the time to reach the correct temperature varied fairly significantly depending on the mains voltage, making it necessary to monitor the temperature on each run to be certain the correct temperature was reached. I built an oven control circuit, which measures the temperature and turns the oven off at the appropriate time.

To make assembly easier, I make a stencil from 80gm printer paper, punching 1mm dia holes for most pads and cutting larger pads and 'slits' for IC's with a scalpel. I use Zig 2-way glue (which when dry is 'repositionable') so that the stencil can be positioned accurately on the PCB and stay in position. The stencil can be used several times and is a lot quicker and neater than soldering by hand, although the stencil is not reusable once the solder paste has dried on it.

The results I get are good, with very few bridges or opens and a much neater appearance than hand soldering.

Richard Townsend

Excellent suggestion Richard, just the kind of low-price-but-it-works technique we like here at EPE*!*

A Digital VFO with LCD Graphics Display (Nov 2009) – UPDATE!

Dear Editor

My digital VFO project was published in *EPE* in November 2009. The demise of Geocities and their hosted websites means that the information explaining to readers where they can obtain downloads of the DDS VFO software and the updates mentioned in that article is no longer valid.

I now have a new website where this information can be downloaded, as well as new details for using the DDS VFO with different IF offsets etc.

The new website is at: **www.zl2pd.com**.

Andrew Woodfield, ZL2PD
By email

Thanks for the update Andrew; an important reminder that information on the web can be vulnerable to DHS (disappearing host syndrome)!

AVG anti-virus recommendation

Dear Editor

I've just read the Aug'10 *Net Work* page, and was very interested in Alan Winstanley's comments on anti-virus programs. I am now running AVG and I'm very pleased with its performance. Prior to AVG, I used both Norton and McAfee, but both these programs let Trojans onto my PC with NO warning. However, AVG has performed beautifully, warning me and stopping these intrusions.

I must admit I'm rather puzzled as to why two (not cheap) programmes failed on this front. My machine is now protected with a two-year subscription to AVG, and I hope they maintain their vigilance.

Thanks for the excellent *Net Work* page in *EPE* – I've been reading this mag' since the late 70s, and I hope you guys keep going strong!

Ken Dobbs, by email

Net Work *author and* EPE *online editor Alan Winstanley replies:*

Many thanks for your feedback, and it's great to hear that you enjoy reading Net Work*. I admit that my recent experiences with various anti-virus programs have knocked my confidence somewhat. AVG has a number of attractive features and I will be reviewing my annual anti-virus software licences very closely next time!*

I'm delighted to hear that you've been with us for so long – you might like my brand new website at **www.epemag.net**, *which is a rolling project of mine.*

Making PCBs

Dear Editor

I was very interested in Tony Thompson's article on *How to make your own PCBs* in the Aug'10 issue of *EPE*, as his experiences closely match my own over the last few years. I would like to add a couple of points that may be of use to others.

First, I have used the Seno SN110 developer with complete success. However, during the recent cold winter, when the developer had been stored in an unheated workshop at around zero degrees, it would not work at all. There must, therefore, be a lower operating temperature. I have asked Seno about this, but not yet received a reply.

Second, there are two films by the name of Jetstar, which are specially formulated for the production of PCB transparencies in inkjet printers. The standard version is suitable for use only with printers that use dye-based ink. The premium version, which is more than twice the price, is suitable for either dye-based or pigment-based ink.

I have used the standard version very successfully with my Canon iP4600 printer. There is a complication in that this printer uses both dye-based and pigment-based inks, and there is no clear indication which ink is used for which function. Canon recommend the 'Other Photo Paper' setting, and I have obtained equally good results with 'Matte Photo Paper', so these must use the dye-based ink.

Although the transparencies are black and white, I find that the colour setting on the printer gives a denser image. The printer registration is so good that two passes can be used to increase the image density if required.

Both the Seno products and the Jetstar film can be obtained from Rapid Electronics (**www.rapidonline.com**). I have no connection with this company other than as a satisfied customer; their next day delivery really is just that (and free if you spend more than £30).

I hope this information will be of interest, and use, to some of your readers.

Dr John Nelson, Leeds, by email

Thank you for sharing your experience John – there really is no substitute for hearing the results of hands-on experimentation. Incidently, ESR Electronic Components stock Seno products and it might prove valuable to checkout their website at: **www.esr.co.uk**

Adding notes to PDFs

Dear Editor

In August's *Editorial* you wrote: 'A nice feature of the iPad is that in the next iteration of the device's operating system you will be able to highlight text and add your own notes and bookmarks to PDFs, including presumably PDFs of articles and projects from *EPE*. It is little 'value-added' features like this that will help to make the online version of books and magazines just as flexible and useful as the printed ones.'

Maybe you are not aware, but these features are already available to PC users when they use the free Foxit PDF reader. This can be obtained from **www.foxitsoftware.com**.

I find the ability to add comments extremely useful, and add my own notes to downloaded data sheets; for example, I append software snippets to PIC data sheets, as well as general buying information.

David Sims, by email

Top tip David! Thank you, I've not heard of Foxit, and hope that other readers will take your advice and annotate their PDFs.

Recycle It! – Watchcase opener

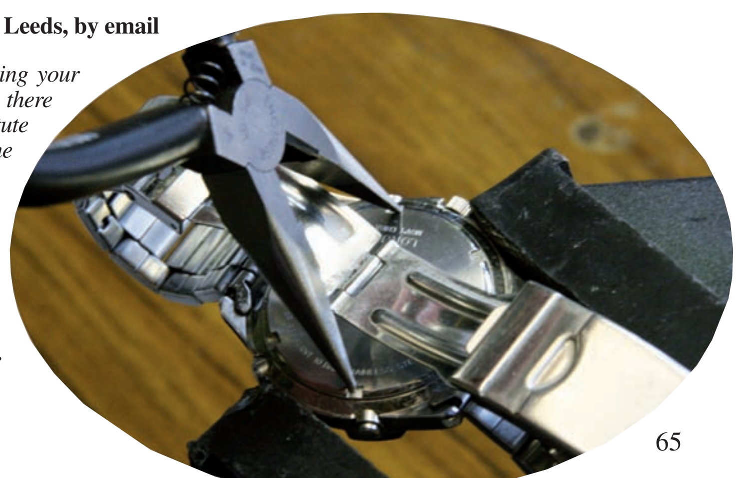
Dear Editor

Readers without the specialised watchcase opener mentioned in August's *Recycle It!* article could try the method in the attached photograph – however, please note that success (damaging neither watch, pliers nor fingers) depends on the skill of the operator!

Here's a suggestion: how about a readers' small advert page? *Practical Wireless* manages this; a small charge is made (subscribers are exempt though). There would be restrictions on word count and number of ads per person per month. Usual classifications are 'FOR SALE' and 'WANTED', with requests for help/data being accepted. Could *EPE* find a page a month for this valuable service? Some casual readers might become subscribers just to avoid missing the monthly adverts!

Godfrey Manning G4GLM,
by email

Good to hear from you Godfrey. I like the ingenuity of your watch-opening technique, but would certainly second your advice to 'be careful!'. I will consider your suggestion for a small ads page, but should warn that we have enough trouble squeezing all our editorial and conventional ads into each issue, so adding an extra page of readers' adverts may prove to be difficult.



Net Work

Alan Winstanley

Keep calm and carry on

With a new economic order well and truly here, many of us are facing tougher times coping in the teeth of a recessionary era. Life seems to be about getting back to basics, downsizing and re-aligning our expectations to cope with more straitened circumstances. I cheerfully sent the Publisher of *EPE* a 'Keep Calm and Carry On' coffee mug (after the WW2 Ministry of Information motto) and I have a poster saying the same on my office wall!

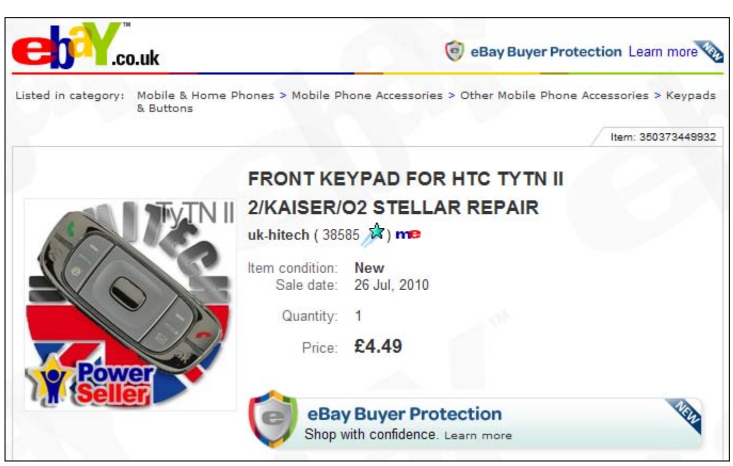
This month's *Net Work* suggests some ways in which the Internet can help in today's recessionary new order. Just like running a business, keeping one's finances on the right track involves looking after one's cash flow. Obvious ways of generating useful cash include trying your hand at eBay, turning unwanted items into cash. However, there is an awful lot of competition and sometimes pot-luck is needed too, so it's best to have realistic expectations as it's hard to predict what may happen. Lots of little sales can build up into tidy sums though, so why not scout around the home and workshop to see what's worth selling. Build up a useful pile of packaging materials, and you can print postage labels online using eBay's Postage Centre for convenience.

You can, of course, also source everyday and obscure items on eBay, which saves on travel costs and the item is delivered to your door. There are many bargains to be had on eBay for workshop test equipment or electronic components too. Many small shops are selling regularly on eBay so don't feel guilty about neglecting the High Street trader: many are adapting well to our Internet-enabled times.

Make do and mend

Hobby electronics is an absorbing pastime founded on the principles of resourcefulness and making do with limited resources, so as finances tighten once again, it's no surprise that our *Recycle It!* feature is proving immensely popular. We electronics hobbyists are well equipped to 'beat the system' by repairing things for ourselves – every successful repair is a satisfying and morale-boosting minor victory. 'Make do and mend' is a mantra worthy of our times, so if you own something that needs spares or minor repairs then spending some time researching the web can reap dividends: has anyone else had the same problem, and where did they find the spares? Is a repair manual downloadable (essential for laptop repairs)? Google is your friend at these times – you might stumble upon a forum containing the answers you need.

Recent personal successes include sourcing a new PDA keypad and a touch digitiser for my TomTom Go satnav, which had been scarred by a nasty scrape on its screen. Some online research confirmed that the touchscreen mounted in front of the LCD was replaceable, so a $13 digitiser screen is currently winging its way from China. Even then, I had to search very hard: I eventually found a well-rated seller on **eBay.com** under cellphone accessories who shipped worldwide – job done! If you can't find what you need, you can set up a Search in eBay to receive a future email alert when an item is listed.



eBay is a prime source of obscure spare parts for DIY repairs

A Compaq laptop was repaired using a replacement DC socket sourced from eBay, and although using a Dremel cutting disc to chop out the old one was rather nerve-wracking (thanks to Brian Brooks at Magenta Electronics for the tip though!), the net cost was just a couple of pounds, as opposed to scrapping the laptop altogether.

One's quest for spare parts or repair manuals can almost become an obsession, but it can save valuable hard-earned cash, which is the name of the game in today's economy. To trade on eBay you will need a PayPal account (and hence, a current or cheque account) to accept payments. Cash is drawn down from your PayPal account into your nominated current account, or you can use PayPal to pay for other purchases. PayPal's website (**paypal.co.uk/**) is deceptively simple to navigate, but it unfolds the more deeply you explore.

Another prime source is Amazon, and it's again wise to compare prices closely: today, for example, I received a new Cateye LED light for my mountain bike from **Amazon.co.uk,** which appears to be imported via **Amazon.de:** the price was 30% cheaper than a similar item listed elsewhere on Amazon. The only difference was the lack of a handlebar bracket, which a quick check on Cateye's website confirmed that I didn't need one anyway because I already had one. Another minor victory!

Bob-a-job

Another way in which the Internet can help in these tough times includes job-hunting websites such as **Jobsite.co.uk** and **Monster.co.uk**, or the equivalents in your country. One trick is to tailor your CV/biog to focus on different keywords that a potential employer might search for. For example, you might emphasise some ISO Quality Assurance experience in one CV and your technical electronics expertise in another version. Multiple profiles can be configured, so that vacancies are emailed to you depending on your postcode, catchment area or job descriptions. It is critical to keep your email address up to date and check it regularly.

Without doubt, the Internet is the fastest way of learning about job vacancies, but online recruitment is also, sadly, a prime source for scams: beware of bogus vacancies on fraudulent websites that are published by Eastern European criminal gangs seeking to recruit gullible money launderers or money mules. Take a look at **www.bobbear.co.uk**, which tackles these criminal websites head on – thousands of them are listed. In Britain, even if you unknowingly become involved in money laundering (typically by accepting cash into your account, retaining 10% and forwarding the rest to the scammers) then you become criminally liable. **Remember that a genuine recruitment website will never ask you for your bank account details**.

In today's new economy, life is all about keeping calm and carrying on. When shopping around, the web is the natural place to start, so save yourself cash by becoming a savvy surfer.

Next month, I'll suggest more money-saving Internet tips, in the meantime, here's wishing you success in your endeavours. You can email me at: **alan@epemag.demon.co.uk** or write to the editor at: **editorial@wimborne.co.uk**.

DIRECT BOOK SERVICE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS AND CD-ROMS SEE THE UK SHOP ON OUR WEBSITE – www.epemag.com

All prices include UK postage

NEW

Electronics Teach-In 3

FREE CD-ROM

The three sections of this book cover a very wide range of subjects that will interest everyone involved in electronics, from hobbyists and students to professionals. The first 80-odd pages of Teach-In 3 are dedicated to *Circuit Surgery*, the regular *EPE* clinic dealing with readers' queries on various circuit design and application problems – everything from voltage regulation to using SPICE circuit simulation software.

The second section – *Practically Speaking* – covers the practical aspects of electronics construction. Again, a whole range of subjects, from soldering to avoiding problems with static electricity and indentifying components, are covered.

Finally, our collection of *Ingenuity Unlimited* circuits provides over 40 different circuit designs submitted by the readers of *EPE*.

The free cover-mounted CD-ROM is the complete *Electronics Teach-In 1* book, which provides a broad-based introduction to electronics in PDF form, plus interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In 1 series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In 1 series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC. There is also a MW/LW Radio project in the series.

The contents of the book and Free CD-ROM have been reprinted from past issues of *EPE*.

160 pages+CD-ROM | **Order code ETI3** | **£8.50**

THE AMATEUR SCIENTIST 3·0 CD-ROM

CD-ROM

The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.

Plus over 1,000 pages of helpful science techniques that never appeared in *Scientific American*.

Exciting science projects in: Astronomy; Earth Science; Biology; Physics; Chemistry; Weather . . . and much more! The most complete resource ever assembled for hobbyists, and professionals looking for novel solutions to research problems.

Suitable for Mac, Windows, Linux or UNIX. 32MB RAM minimum, Netscape 4.0 or higher or Internet Explorer 4.0 or higher.

Over 1,000 projects

CD-ROM | **Order code ASICD-ROM** | **£19.95**

PROJECT CONSTRUCTION

IC 555 PROJECTS
E. A. Parr

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are over 70 circuit diagrams and descriptions covering basic and general circuits, motor car and model railway circuits, alarms and noise makers as well as a section on 556, 558 and 559 timers. (Note. No construction details are given.) A reference book of invaluable use to all those who have any interest in electronics, be they professional engineers or designers, students or hobbyists.

167 pages | **Order code BP44** | **£5.49**

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers and crystal calibrators.

104 pages | **Order code BP267** | **£5.49**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages | **Order code BP392** | **£5.99**

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:-

AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe. The designs are suitable for both newcomers and more experienced hobbyists.

104 pages | **Order code BP248** | **£4.49**

COMPUTING

ELECTRONICS TEACH-IN 2
USING PIC MICROCONTROLLERS A PRACTICAL INTRODUCTION

FREE CD-ROM

This *Teach-In* series of articles was originally published in *EPE* in 2008 and, following demand from readers, has now been collected together in the *Electronics Teach-In 2* book.

The series is aimed at those using PIC microcontrollers for the first time. Each part of the series includes breadboard layouts to aid understanding and a simple programmer project is provided.

Also included are 29 *PIC N' Mix* articles, also republished from *EPE*. These provide a host of practical programming and interfacing information, mainly for those that have already got to grips with using PIC microcontrollers.

An extra four part beginners guide to using the C programing language for PIC microcontrollers is also included.

The free cover-mounted CD-ROM contains all of the software for the *Teach-In 2* series and *PIC N' Mix* articles in this book, plus a range of items from Microchip – the manufacturers of the PIC microcontrollers. The material has been compiled by Wimborne Publishing Ltd. with the assistance of Microchip Technology Inc.

The Microchip items are: MPLAB Integrated Development Environment V8.20; Microchip Advance Parts Selector V2.32; Treelink; Motor Control Solutions; 16-bit Embedded Solutions; 16-bit Tool Solutions; Human Interface Solutions; 8-bit PIC Microcontrollers; PIC24 Microntrollers; PIC32 Microcontroller Family with USB On-The-Go; dsPIC Digital Signal Controllers.

160 pages + CD-ROM | **Order code ETI2** | **£9.50**

COMPUTING FOR THE OLDER GENERATION
Jim Gatenby

Among the many practical and useful ideas for using your PC that are covered in this book are: Choosing, setting up and understanding your computer and its main components. Writing letters, leaflets, invitations, etc., and other word processing jobs. Keeping track of your finances using a spreadsheet. Recording details of holidays and other ideas using a database. Using the Internet to find useful information, and email to keep in touch with family and friends. Making 'back-up' copies of your work and checking for viruses. How to use Windows XP to help people with impaired vision, hearing or mobility.

308 pages | **Order code BP601** | **£8.99**

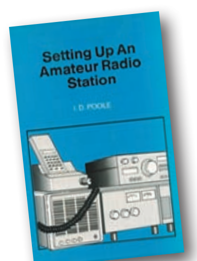
RADIO

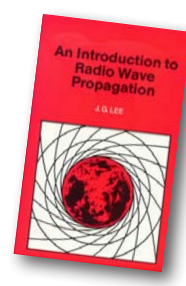
SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

Temporarily out of print





AN INTRODUCTION TO RADIO WAVE PROPOGATION
J.G. Lee

Radio wave propogation is one of the more important discoveries made in the early 20th century. Although technology lagged behind early experimenters pursued this newly discovered phenomenon eagerly for, in understanding the physics of propagation, they were discovering more about our Universe and its workings.

Radio wave propagation has its origins in the world of solar physics. The Sun's radiation provides the mechanism for the formation of the ionosphere. How the ionosphere is formed, and how it provides long-distance communication, is carefully explained. Non-ionospheric propagation, including 'moonbounce' or satellite communications, is covered as well.

This book has been written with the average electronic hobbyist in mind. Technical language and mathematics have been kept to a minimum in order to present a broad, yet clear, picture of the subject. The radio amateur, as well as the short-wave listener, will find explanations of the propogation phenomena which both experience in their pursuit of communications enjoyment.

116 pages | **Order code BP293** | **£4.45**

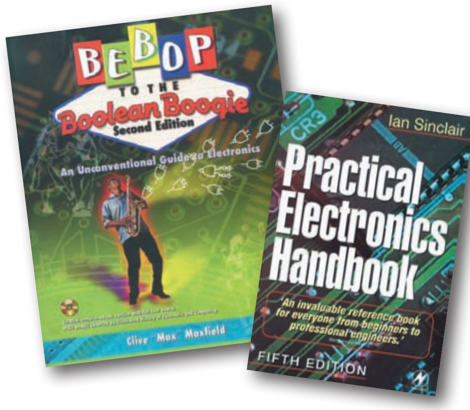
THEORY AND REFERENCE

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (call me Max) Maxfield

This book gives the "big picture" of digital electronics. This in-depth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

470 pages **Order code BEB1** **£35.99**



BEBOP BYTES BACK (and the Bebopter Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

Over 800 pages in Adobe Acrobat format

CD-ROM **Order code BEB2 CD-ROM** **£21.95**

INTERFACING PIC MICROCONTROLLERS
Martin Bates

An essential guide to PIC interfacing techniques, using circuit simulation to aid learning.

Explore in detail microcontroller interfacing techniques using the popular PIC 16F877. Work through step-by-step examples interactively using circuit simulation software, supplied as assembly source code.

Interfacing PIC Microcontrollers provides a thorough introduction to interfacing techniques for students, hobbyists and engineers looking to take their knowledge of PIC application development to the next level. Each chapter ends with suggestions for further applications, based on the examples given, and numerous line drawings illustrate application of the hardware.

Step-by-step examples in assembly language are used to illustrate a comprehensive set of interfaces, and these can be run interactively on circuit simulation software, used to aid understanding without the need to build real hardware.

A companion website includes all examples in the text which cam be downloaded together with a free version of Proteus's ISIS Lite.

298 pages **Order code NE48** **£30.99**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

102 pages **Order code BP239** **£5.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold

The first part of this book covers standard operational amplifer based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signalgenerator, simple video fader, and many more.

120 pages **Order code BP335** **£5.45**

PRACTICAL ELECTRONICS HANDBOOK – Fifth Edition. Ian Sinclair

Provides a practical and comprehensive collection of circuits, rules of thumb and design data for professional engineers, students and enthusaists, and therefore enough background to allow the understanding and development of a range of basic circuits.

Contents: Passive components, Active discrete components, Circuits, Linear I.C.s, Energy conversion components, Digital I.C.s, Microprocessors and microprocessor systems, Transferring digital data, Digital-analogue conversions, Computer aids in electronics, Hardware components and practical work, Micro-controllers and PLCs, Digital broadcasting, Electronic security.

440 pages **Order code NE21** **£32.50**

MUSIC, AUDIO AND VIDEO

QUICK GUIDE TO DIGITAL AUDIO RECORDING
Ian Waugh

Covers:

- What computer system you need
- Sound and digital audio essentials
- What to look for in a sound card
- What effects to use
- The art of mixing
- How to burn your music to CD
- How to post your songs on the Web

All modern music recordings use digital audio technology. Now everyone with a compouter can produce CD-quality recordings and this book shows you how. Written in a clear and straightforward style, it explains what digital audio recording is, how to use it, the equipment you need, what sort of software is available and how to achieve professional results.

Computer-based recording is the future of music and this book shows how you can join the revolution now.

208 pages **Order code PC121** **£7.95**

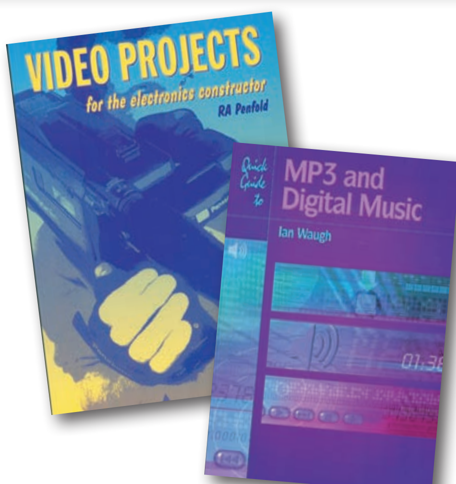
QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

60 pages **Order code PC119** **£7.45**



ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold

This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

109 pages **Order code BP356** **£5.45**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, computer control interface, 12 volt mains power supply.

Temporarily out of print

ALL PRICES INCLUDE UK POST & PACKING

FAULT FINDING, CIRCUITS AND DESIGN

STARTING ELECTRONICS
Third Edition
Keith brindley

BOOK + CD-ROM

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits. Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£13.99**

HOW ELECTRONIC THINGS WORK – AND WHAT TO DO WHEN THEY DON'T
Robert Goodman

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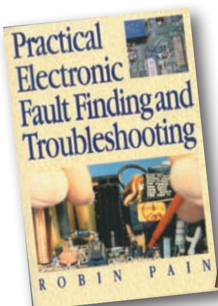

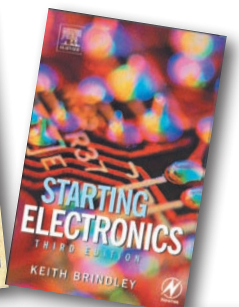

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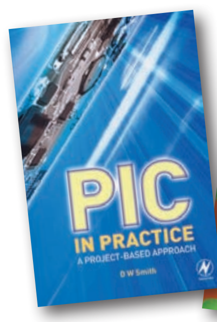

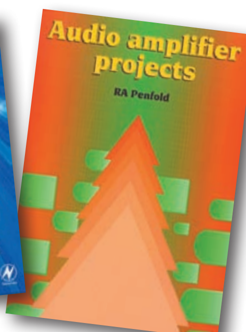

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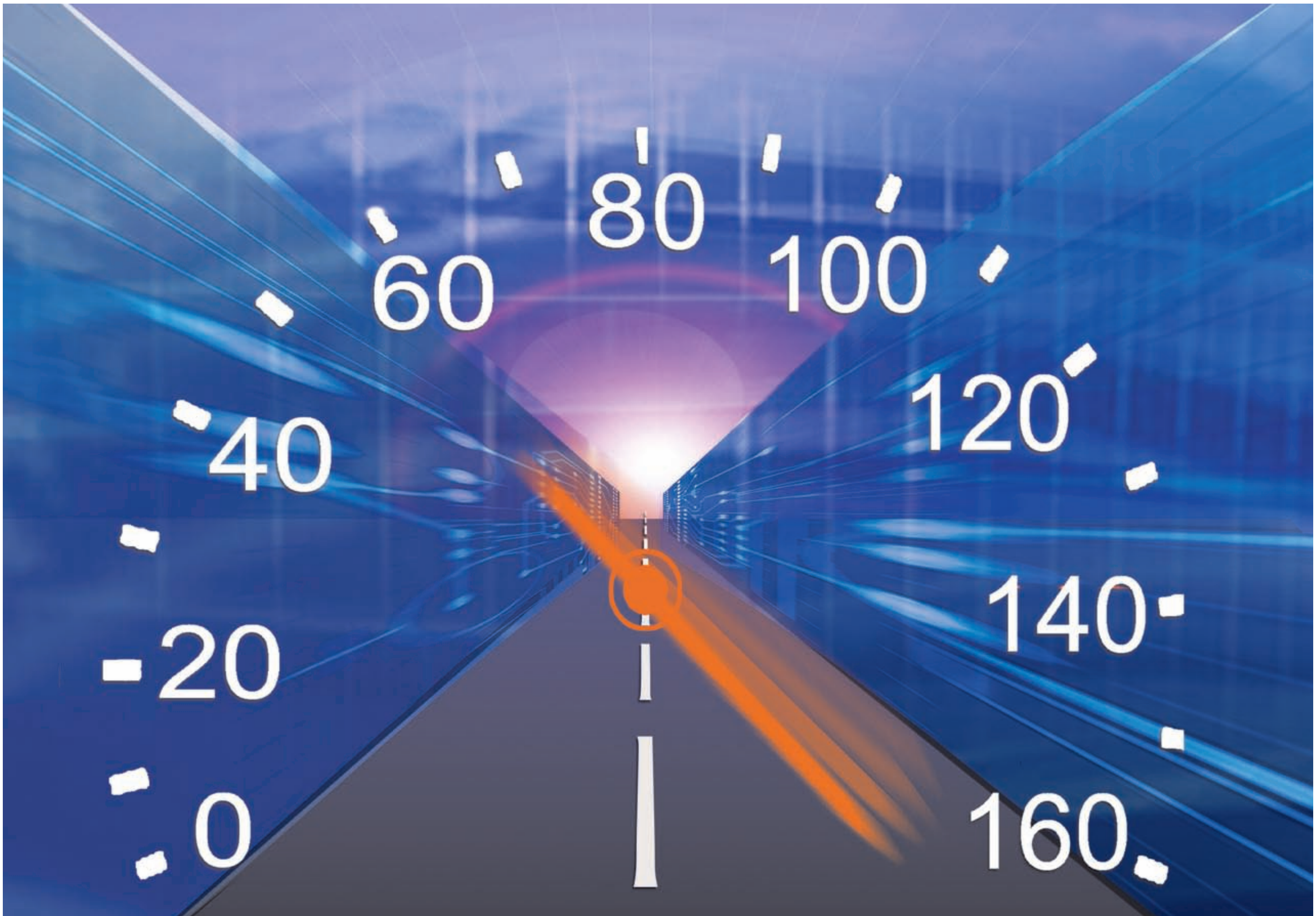
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